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New Turbine Installation of Pacific Gas & Electric Co.

15,000-KW. HORIZONTAL TURBINE REPLACES RECIPROCATING UNITS; PLANT HISTORY; TESTING METHODS. BY CHARLES W. GEIGER

STATION "A" of the Pacific Gas & Electric Co., located in the Petraro district at San Francisco, has been enlarged by the installation of a new 15,000-kw. turbine which was put in operation in July, 1919. With this new installation, Station "A" now produces approximately 1,000,000 kw.-hr. per day and will soon generate 1,200,000 kw.-hr. daily.

In size of output, this station is said to be the largest plant west of Chicago. The building is an immense brick structure 433 ft. long and 133 ft. wide, and 80 ft. from its fireroom floor to its steel ribbed roof of galvanized sheet iron.

A 1500-kw. reciprocating engine was removed to make place for the new turbine, and the latter unit with ten times the capacity of the engine takes up less room. The turbine occupies much less floor space and needs no more head room.

The new turbine is a Curtis horizontal type and the first of its kind to be installed in Station "A." It has proved a big help to the Pacific Gas & Electric Co. in both directions. Twenty-five years ago and engine which could furnish a horsepower-hour on a steam con-

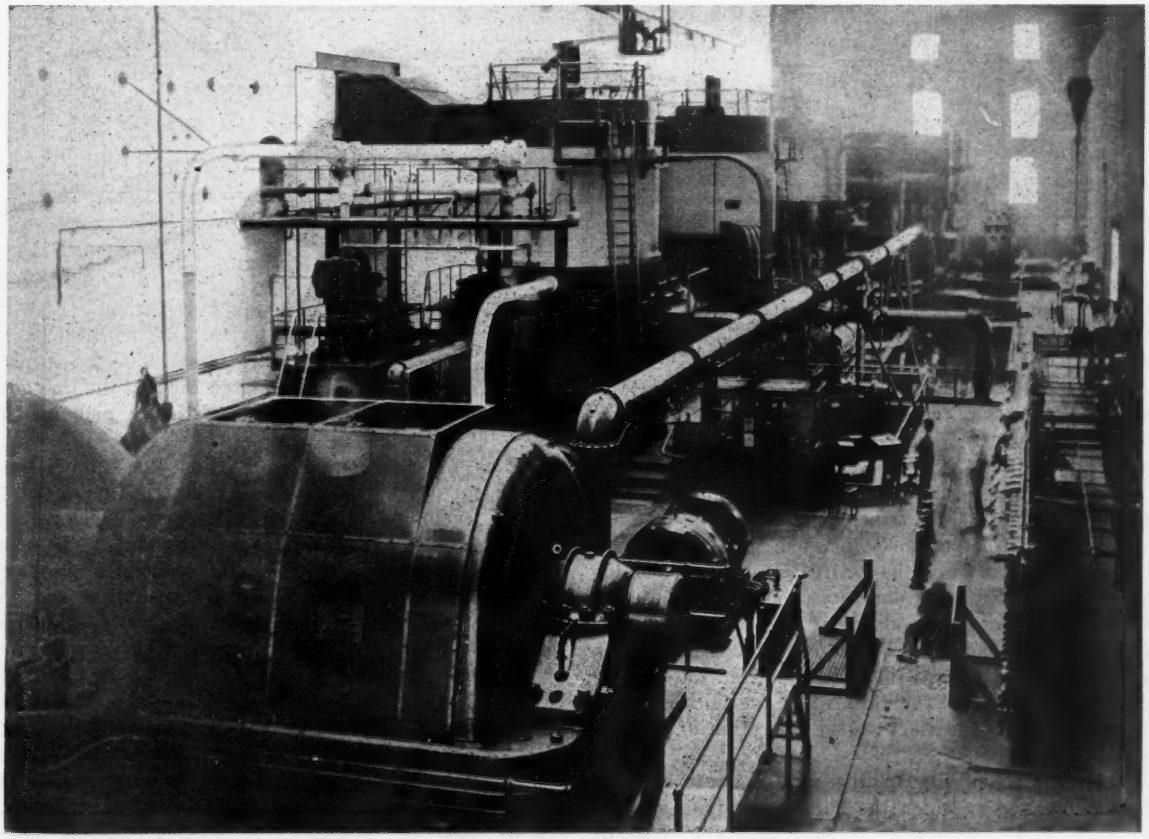


FIG. 1. GENERAL VIEW OF TURBINE ROOM LOOKING SOUTH

sumption of 20 lb. was considered a good machine. Today the turbines at Station A are giving a horsepower-hour on a steam consumption of 10½ lb. Thus they have accomplished a saving of nearly one-half in fuel and reduced the repair account 25 per cent and the labor 14 per cent.

This new turbine is the fourth to be installed by the Pacific Gas & Electric Co. at Station "A." The first turbine was installed in 1910. This was a 12,000-kw. vertical. In 1912 the second turbine was installed, and the third in 1914. The last two were vertical type, of 15,000 kw. each.

Each time one of these turbines has been installed a 1500-kw. reciprocating engine was removed to make space for the turbine.

Because of the superiority of the turbine over the reciprocating engine, it may be of interest to know something of the past history of Station "A."

The plant was built in 1901. Originally it contained five units each of 1500-kw. capacity, and provision was made, should conditions ever warrant such a step, to double the length of the building to accommodate five more units of similar capacity. Conditions did warrant it, and not only was the building extended to cover the entire lot before the first installment was completed, but, on account of the rapid increase in the use of electricity, units 9 and 10 were increased to 3500-kw. capacity.

Six of the engines were standard compound type of 2200 hp. each, two were triple expansion type of 2200 hp. each, and two were 4800 hp. each.

A division wall runs the entire length of the building and makes of it two tremendous rooms of equal size; the long room on the east side of the double building contained the 27 boilers, 6 boiler feed pumps, salt water fire pump, 5 economizers, the 3 exhaust feed-water heaters, 4 fuel oil pumps, 4 fuel oil heaters, and all the steam and water piping necessary to the operation of the big boiler plant.

The natural solidity of the site accounts for the splendid manner in which the building and its foundation have stood earthquake tremors and the constant vibration of the machinery.

Operates in Parallel with Hydroelectric System

At the present time the Pacific Gas & Electric Co. has operating and tied together as one large generating unit 14 hydroelectric plants and four steam stations. Situated as they are in the Sierra Nevada Mountains, the hydroelectric plants are connected to the main load centers, such as San Francisco, Oakland, Sacramento and San Jose, with transmission lines many miles in length which are susceptible to some disorders, the main trouble being due to weather conditions. Lightning and the wind sometimes cause interruptions over these lines and not infrequently serious damage has been done by large birds flying against the wires and putting a short on the system which has taken some time to locate and repair. Consequently, it has been found necessary in line with the company's policy of continuous service to maintain steam power plants in the larger load centers, each plant being capable of carrying all the connected load in the district which it is meant to supply; thus, in San Francisco Station "A" with four turbines having a capacity of 57,000 kw., in Oakland Station "C" with 21,000, and in Sacramento Station "B" with 5000 kw. Ordinarily the turbine generators are connected in parallel with the transmission line and then, if the line goes out of service, the turbines automatically pick up the load.

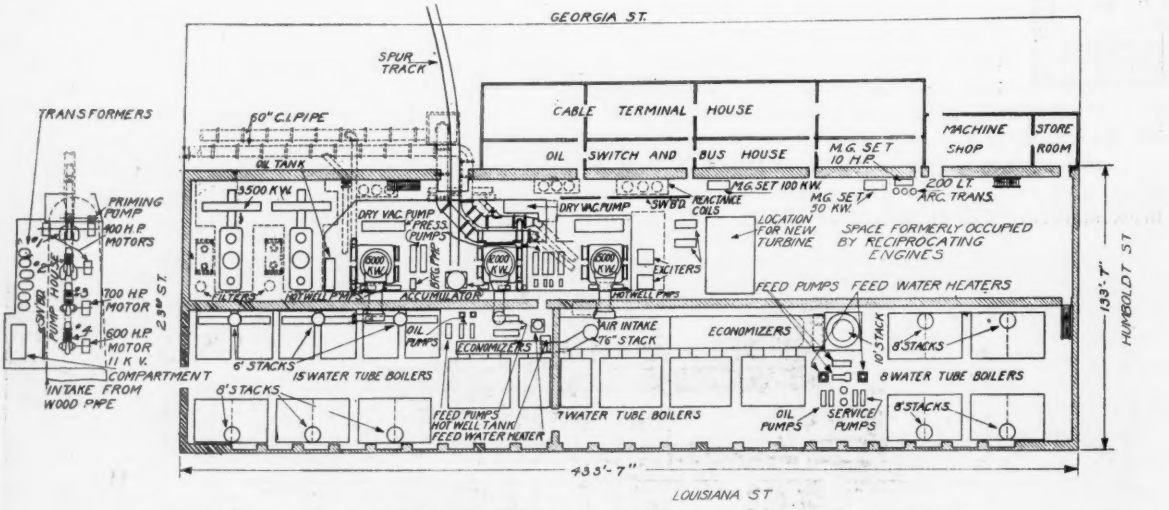


FIG. 2. GENERAL LAYOUT OF STATION A, PACIFIC GAS & ELECTRIC CO. PLANT

Plans for the completed Station "A" have been worked out by the Pacific Gas & Electric Co., with the idea of developing the maximum capacity which is considered advisable to generate at this plant. The completed plans show a feasible and economical development of 100,000 kw. At the time of installing the last 15,000-kw. vertical turbine, the company was planning the installation of the fourth turbine, which, on account of the higher relative speed, was decided to be of the horizontal type. Now, with regard to the present plant and the reason for planning a station with such a capacity, it was considered essential that San Francisco should have enough steam generating capacity to carry its maximum demand. In making this statement, it should not be construed to mean that no hydroelectric power is used by San Francisco, but that in case of emergency,

such as line trouble, San Francisco will not be without service in any section. Furthermore, if such emergencies occur at off peak hours, it will be possible to supply the hydroelectric system with current to the station capacity. Thus, for example, San Jose will have three sources of supply; that is, from the Electra lines, the lines from Oakland (steam and hydroelectric) and from San Francisco steam station. It is an apparent fact also that the greatest assistance to the hydroelectric department in case of shortage of capacity on that system is first to relieve it of load on the extreme ends of the lines, and second, if necessary to supply current from these terminals, thus with a steam plant in San Francisco of sufficient capacity to carry the San Francisco peak, the first load to take off the transmission lines is the San Francisco load; and if this shortage of current occurs at off peak times, it is possible to feed back on the line from Station "A."

Station "A" has the distinction of being the largest single generating plant owned by the company, and in emergency cases has generated ⅓ of the company's entire output. Its general efficiency compares very favorably with the best managed stations in the United States, and the class of service given is equal to any, notwithstanding the fact that the station is used very largely as a stand-by to the hydroelectric system and generates only what that system cannot supply. In the meantime, it stands ready to absorb a load of 57,000 kw. instantly in case the hydroelectric supply is cut off. The steam station is operated 365 days yearly.

This efficiency of standby service is impossible with the reciprocating engines, and has been made possible only by the advent of the steam turbine. The steam turbine has an efficiency curve that is practically flat from one-third load to full load. This high steam efficiency under all conditions, coupled with the small cost of labor to operate, the low cost of maintenance, and the perfect synchronous operation, due to evenness of the impulse on the turbine blades and the rotary motion, make it the operators' ideal.

The high efficiency in steam consumption is due to the possibility of expanding the steam indefinitely, in the multiple number of stages, and to accomplish this expansion a high vacuum is necessary; therefore it is customary to install with the turbine a wet vacuum pump to rid the condenser of water and a dry vacuum pump of high efficiency to carry off the noncondensing vapors. This would appear to increase the number of auxiliaries in proportion to the turbine capacity. It does not do so, however, as tests have shown that the dry vacuum pump in a 15,000-kw. turbine requires only 25 hp., which is practically the same as the vacuum pump on the former 1500-kw. reciprocating engines. Owing to the remarkable saving in the amount of steam required, the company has been able almost to double the capacity of Station "A" without adding any more boilers.

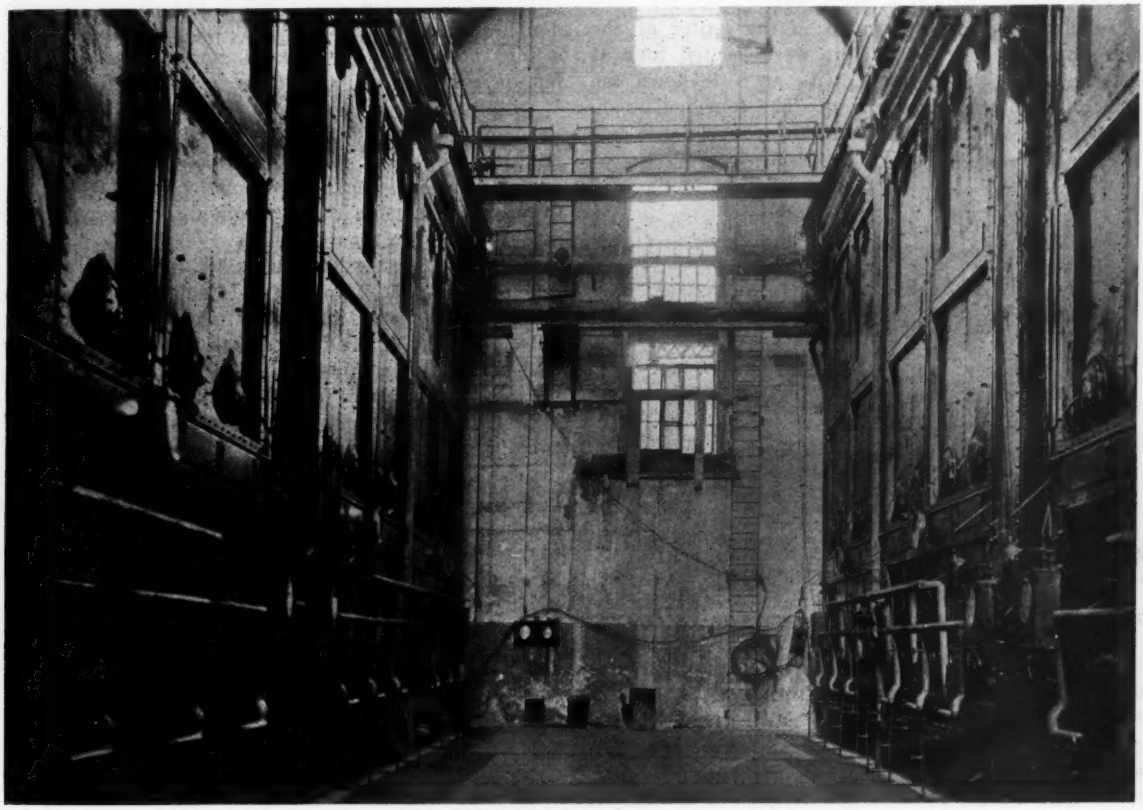


FIG. 3. NEW BOILERS IN STATION A, FOUR TO RIGHT ARE FOUR-PASS, TO THE LEFT THREE-PASS; ONE MAN TENDS EIGHT OIL-FIRED BOILERS

The time arrived, however, when more generating capacity necessitated more boilers, and to install more boilers it was necessary to remodel the boiler room. In doing this, a fine plan has been developed which not only allowed more capacity but also simplified the boiler room and made it possible to install more capacity at a very low first cost and a subsequent low operating cost.

As previously stated, the boiler room was originally equipped with 27 boilers; but, with the installation of the new 15,000-kw. horizontal turbine, four of the original boilers were removed and eight 822-hp. vertical water-tube boilers were installed. The boilers removed were of the horizontal type and had been in operation since 1901. With the installation of the eight boilers, four new steel stacks were erected, each stack being 8 ft. in diameter and 157 ft. in height.

The old boilers were located in the center of the boiler room, but the new boilers were located four at each side of the boiler room, with an aisle down the center, as is shown in the photo. The four boilers on the right side are four-pass and the four on the left side are three-pass. Readings taken on the four-pass showed a marked decrease over the three-pass in the temperature of the escaping flue gas at all ratings, indicating that the economy of the new arrangement is of natural advantage.

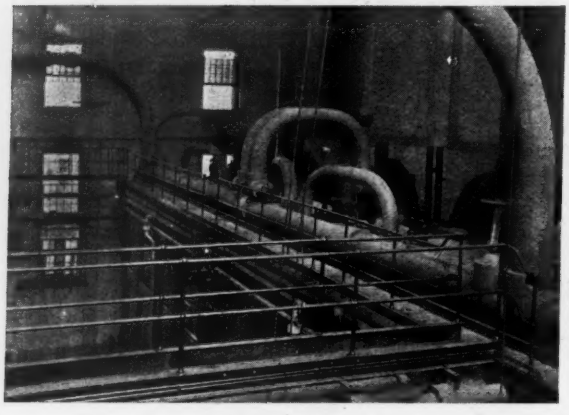


FIG. 4. STEAM LEADS AND HEADER FOR FOUR-PASS BOILERS

The boilers are capable of generating 900,000 lb. per hour of water into steam at a pressure of 200 lb. It is not often that the maximum capacity of the plant is needed, yet at certain seasons it is quite usual to evaporate 5000 tons of water daily.

The plant uses 5000 barrels of fuel oil a day at the maximum and 2500 barrels a day on the average. To handle this great amount of oil is about the easiest and simplest work about the station. Elaborate storage tanks built of steel have been provided of a size sufficient to store a large reserve supply to protect the plant against the risks of delayed delivery. Sometimes the railroad company cannot get oil tank cars through from the wells, sometimes the oil carrying steamers are delayed. Despite all of these uncertainties, however, the station must be kept going. The forethought of the company management in supplying such ample storage capacity has averted shut-downs. When the oil company has been short of oil, the large reserve storage has given it a place from which to secure a temporary supply. Steamers carrying 35,000 barrels of fuel oil come alongside the company's wharf near the power plant and discharge their oil cargoes directly into the storage tanks in 50 hr. As there are two separate pipe lines, the oil cargo from two oil boats can be pumped out at the same time. Probably no other electric light and power plant in the world can handle its fuel in such large quantities and so quickly as can Station "A."

The oil is heated to a temperature of 165 to 175 deg. and fed to the burners at a pressure of 65 lb. The fuel oil pumps discharge into a common pipe 4 in. in diameter that leads to the burners. The burners used are of special design, having been made by the company's workmen, and give excellent service. Steam pipe for atomizing the oil is connected to the burner line by a double connection manifold. Steam is supplied through a 3/16-in. hole to the burner at normal load of 200 lb., but on a heavy load the steam is by-passed through a ½-in. pipe.

Approximately 30,000 cu. ft. of make-up water is used at the plant daily, the remaining supply being obtained from the condensers. A saving of 20,000 cu. ft. of water was made daily through the recent changes made by the fire room foreman.

Each of the new boilers has 482 3¼-in. tubes, ranging from 16 to 22 ft. in length. Each boiler is equipped with a boiler meter, and special electric lights are provided for lighting the face of each meter and each gage. The normal steam pressure is 200 lb. The boiler feedwater pressure ranges from 235 to 240 lb. A soot blower is provided for the new boilers with a 2-in. pipe, and the tubes are dusted every night. An automatic valve is provided in the discharge line of each boiler. The following are some of the boiler dimensions: Distance from front to back of boiler, 21 ft. 9 in.; 25 ft. from floor to top of I beam; 27 ft. 11 in. over top of brick work; 27 ft. 7 in. to face of steam outlet; width of furnace, 37 ft. A ⅜-in. by 4-in. slot is placed in front of each boiler at a height of 7 ft. 6 in. for observation purposes. Each furnace has six cleaning doors 12 by 14 in., bricked in opposite baffle to prevent bypass of gases. There is a 2-in. space between the mud drum and brick work with asbestos lining. A 1½-in. space is left between the tubes and the bridge wall.

The main steam header leading from the four-pass boilers to the three-pass is 12 in. in diameter, and from the three-pass to the turbines the header is 16 in. in diameter and is carried within the walls. Auxiliary steam pipes are taken off the main header at four points in the north section and four points in the south section of the boiler-room.

The entire boiler-room is operated by three crews of 34 men each. Only one fireman is required to operate the eight new boilers. In the fire-room are 14 boiler cleaners, one brick layer and helper; two boiler makers do all the repairing. Five firemen and one water tender are on each watch. Four pipefitters are employed throughout the plant (in ordinary times) making repairs and keeping all equipment in good working condition. A well equipped machine shop is provided and a well equipped pipe shop where practically all repairs are made to all equipment at Station "A."

An interesting proposition is the testing of turbines.

For determining the amount of steam used, the water from the condensers is weighed as follows: Four large tanks are used, each capable of holding 2000 lb. of water. Each tank is placed on a platform about 7 ft. above the floor, underneath which is placed a large receiving tank. A 5-in. discharge pipe with quick opening valve takes the water from the bottom of each tank into the receiving tank, from which it flows to the feed pump. The water from the turbine condenser is brought in a 6-in. pipe which runs above the weighing tanks, and over each of these a tee is put on the line with a quick opening valve below it.

When test is to be made, a man is stationed at each scale to weigh and record the amount of water, and two men are below the platform to open the discharge valves on the tanks as they are weighed. One man operates the inlet valves which give the water to the different tanks. Previous to starting the test, all the water is allowed to run into and directly out of one of the tanks, No. 4, for example. Nos. 1, 2 and 3 are closed and the weights of the empty tanks are taken in order that the net weight of water may be determined. At the instant of starting the test, inlet valve No. 1 is opened and No. 4 shut. Number 1 is now filled to a mark about 3 in. from the top and then No. 2 valve is opened and No. 1 shut, and No. 2 shut and so on through No. 4 and back to No. 1 again. Now as soon as No. 1 tank is filled, the man at the scales weighs it and then gives the signal to one of the men below to open the discharge valve. The tank is allowed to drain thoroughly, in order that the tare weight will be constant, then the discharge valve is shut, so that by the time No. 4 is full, No. 1 will be ready to receive the water again. Some idea of the amount of work to be accomplished may be obtained from actual figures taken during the full load test on the 15,000-kw. turbine. The test was of 4 hr. duration and during all that time the water was turned into No. 1 every 2 min. and 5 sec. That meant that nearly 4000 lb. of water was weighed every minute.

The acceptance tests on the turbines were made with great accuracy, and many corrections have to be made on the actual test condition. The electric meters for measuring the power output are carefully tested before and after. The scales on which the water is weighed are tested by means of 50-lb. standard weights, both before and after, enough weights being used to calibrate the scales at about the weight shown when the tank is full of water. Most important of all, however, are the corrections which have to be made for the temperature of the superheated steam, the initial pressure on the steam and the vacuum in the condensers. These items are important, as a slight variation makes quite a difference in the performance of the turbine. For example, take the vacuum in the condensers; one inch of mercury difference in the vacuum will give a difference of about 1 lb. in the water rate; that is, a turbine which will give a kilowatt-hour on 15 lb. of steam at 29 in. of vacuum would require 16 lb. of steam if the vacuum were only 28 in. In the same manner a difference of 12½ deg. F. in the superheat temperature will give a difference of 1 per cent in the water rate, which amounts to 0.15 lb. when the actual water used is 15 lb. per kilowatt-hour, consequently it is necessary that the vacuum, initial pressure and steam temperature be very accurately determined.

For the steam pressure a gage is tested with a dead weight tester so that the correction is only a matter of the difference between the gage reading and the actual pressure. For the superheat and vacuum, the results are not so easily arrived at. For the superheat, a thermometer is placed in the steam pipe of the turbine and a high reading thermometer in the well. Suppose now that this thermometer is immersed to the 100 deg. F. reading and the temperature of the steam is 500 deg. There is 400 deg. of the mercury thread exposed, and from this thread the heat is radiated out through the steam and the mercury contracts, giving a lower temperature reading than should be recorded. To correct this, the temperature of the steam must be taken and by means of a suitable formula the amount to be added to the superheat reading is determined. During one of the tests this correction was as high as 9 deg. F., or ¾ of 1 per cent in the water rate.

The vacuum corrections are still more complicated, for here the readings must be referred to a barometer

FIG. 5. FEED WATER PUMPS AND OIL HEATER IN NORTH SECTION OF PLANT

of 30 in. as well as corrected for temperature. Two mercury columns are used on the condenser and the average reading is taken in the final results. The temperature of the mercury column is obtained in each case and corrections made for radiation from the column, the same as in the case of the superheat thermometer, except that a different formula is used. After this correction has been made, the column readings must be corrected to read as they would have done had the barometer reading been 30 in. To do this a mercurial barometer which has been carefully tested is placed near the turbine and readings taken throughout the test. Corrections are made on it for column temperature and then, when the true reading has been obtained, the difference between this reading and 30 in. is either added or subtracted from the column readings on the condenser, according to whether the correct barometer is below or above 30 in. These corrections when combined may add to the water rate of the turbine or they may subtract from it, depending on whether the conditions of the test are better or worse than the guarantee condition of superheat, initial pressure and vacuum. In one actual case the correction added 6.66 per cent to the water rate, while in another the rate was reduced by 3.76 per cent.

In testing the turbines at Station "A," three 4-hr. runs were made on each machine. The loads for the runs were 7500, 12,000 and 15,000 kw. By making three tests, three points on the efficiency curve of each turbine are obtained, thus making it possible to determine the approximate efficiency at a load from zero to maximum capacity.

Salt Water Pumping Station for Station "A"

The salt water pumping equipment connected with the turbine installation is rather interesting. There are four pumps housed near the water front about 1000 ft. east of the power plant. Two double suction outboard bearing pumps with a capacity of 20,000 gal. per min. are installed, each direct connected to a 400-hp. 500-v. induction motor. Two pumps of 30,000 gal. per minute each, operated by 600 and 700-hp. motors, respectively, are provided. One of the later pumps was installed to take care of the new horizontal turbine. The motors are provided with switchboard, and banks of transformers step down the voltage from 11,000 to 250, 375 and 500 volts. Each bank has its own switch-panel.

There is an air pump in the pump room for creating a vacuum for drawing water up into the centrifugal pumps when starting.

A 60-in. pipe line carries the water to the condensers, while another line the same size carries the water back to the bay again.

At the intake two 60-in. wood stave pipe lines, thoroughly treated, were sunk to the bottom and firmly anchored. This is at all times below the line of the lowest tide.

At the wharf two large gates have been installed so that the water can be shut off from the pipes if necessary. The entrance to the pump pits is guarded by two large screen gates or aprons, so that no floating debris can reach the pumps. These screens are so arranged that they can be raised for cleaning. One is always up while the other is in the water. A substantial building of iron and steel houses the equipment, and this is equipped with a traveling crane.

Taken all in all, Station "A" now has a pumping plant that is well adapted to its needs for some time to come. That the system is effective and the operatives handling it efficient and alert was demonstrated when, during an interruption to the service caused by a transformer burning out, the current was cut off from the motors and the pumps stopped. Yet in less than 30 sec. water was again on the line, and during the interval the vacuum on the turbine condenser dropped but ½ in.

All pumps discharge into a common cast-iron main extending 1000 ft. to the station. After this pipe reaches the station, it has 30 and 36-in. outlets at each condenser, 30-in. to the 12,000-kw. and 36-in. to the 15,000-kw. turbine. Outlets are provided also at each cooler and at other places where salt water may be required. Each outlet is provided with strainers of a standard pattern to intercept any dirt that may have passed the

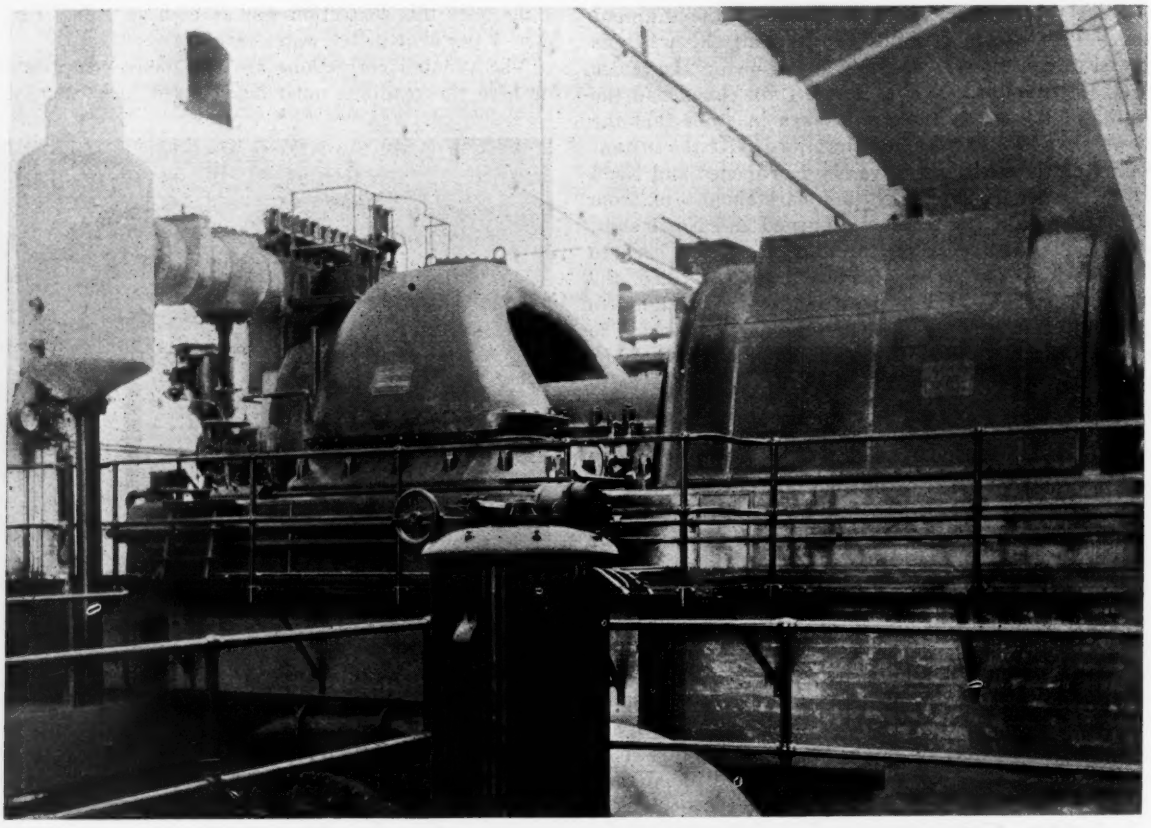


FIG. 6. VIEW OF 15,000-KW. TURBINE SHOWING ALSO TOP OF CONDENSER

primary strainers at the suction end of each pump in the channel.

Preparing New Foundations for the Turbines

When the station was built, it was not known that the reciprocating engines would be replaced by turbine, consequently it may be of interest to know something of the method of preparing new foundations for the turbines.

In order to prepare the foundations for the first 15,000-kw. vertical turbine, it was necessary to remove about 200 cu. yd. of concrete, formerly the foundation of the reciprocating engine. To do this without in any way endangering the switchboard, which was but a few feet distant, or the other equipment in the power house, including the 12,000-kw. turbine less than 20 ft. away, quite a problem was presented.

As it was imperative that the operation of the plant should be in no way jeopardized through this work, the use of a channeling machine was decided upon and the result was a success. A contract was placed for the removal of a total of 195 cu. yd., the time for removal not to exceed four weeks and the concrete to be cut into blocks not exceeding 25 tons. The blocks and fragments were removed by the Pacific Gas & Electric Co. forces as fast as they were loosened. The method followed was to run vertical cuts 3 or 4 ft. apart from top of the concrete blocks to the floor line with the channeling machine. Machine drills were used for driving a series of horizontal holes, and the masses were then loosened from the foundation by the plug and feathering method. Steam was supplied to the channeling machines as well as the drills from the company's boilers at 100 lb. pressure.

Work was carried on uninterruptedly for 25 days. The largest piece of concrete removed contained 20.75 cu. yd. and weighed about 39 tons. The concrete was of an excellent quality and extremely hard, showing that a rich mixture had been used, and its being traversed by anchor bolts in vertical planes added to the difficulty in making the channel cut. The methods used were unique and especially suitable for this kind of work, where flying fragments of concrete in an operating plant are exceedingly dangerous.

When the second 15,000-kw. vertical turbine was installed, two of the old 1500-kw. engines were removed to make place for it. The work of making a place for this turbine was as follows: Some gads weighing 500 lb. each were hammered into the rock with battering rams of 3 tons weight slung from an overhead crane. The action of the gads resembled that of a wedge splitting wood. Through this process the rock was broken up into comparatively small pieces, loaded into railroad cars and taken away. This method proved a complete success in every way.

The distinctive features of this turbine are the seven stages and the extremely large condenser shell. The other vertical turbines have but five stages, with the exception of the installation in 1912, which has six, and while the second 15,000-kw. vertical turbine has exceeded the other vertical turbines in the number of stages, this has been accomplished without any material increase in weight. With regard to the condenser, it has been customary to install auxiliary wings at the sides of the turbine base in order to get enough cooling surface for the quantity of steam consumed by the turbine. But, in the case of the second 15,000-kw. vertical turbine, at the solicitation of the company the base was so designed that enough surface could be installed in the base itself, resulting in a considerable saving in first cost, a large reduction in the amount of floor space required and a more economical unit. The condenser has 6000 tubes and demands 25,000 gal. of salt water every minute.

The result of the test to which this turbine was submitted showed it to be not only all, but more than, the manufacturer expected and claimed for it. While its rating was 15,000-kw., it was demonstrated that it would carry 19,000-kw. continuous without detriment to either the turbine or the generator, and that at an efficiency even higher than was claimed for its most economical point of operation.

In the final test a 15,000-kw. load was carried from about 11 a. m. to 5 p. m., at which time the load was increased to 19,000 kw. and operated until 9 p. m. During the run, the greatest temperature in the generator, as read by the temperature instrument connected to the exploring coils in the armature slots, reached 70 deg. C., while the manufacturer's instructions stated that 90 deg. C. could be carried safely. With regard to the steam consumption of the turbine, the guarantee was exceeded by almost 3 per cent.

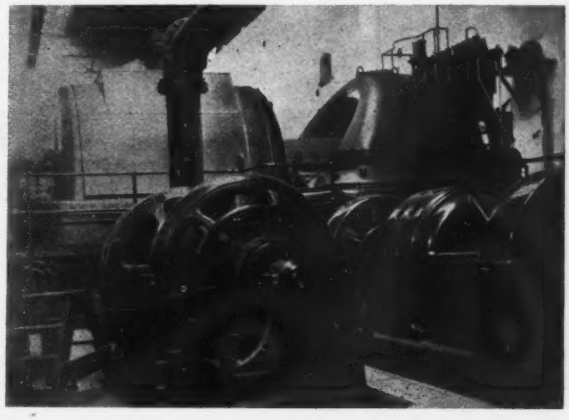


FIG. 7. EXCITER UNITS FOR GENERATORS

In the vertical turbine, the economical peripheral velocity of the turbine wheels is reduced by the use of a number of stages, each of which makes use of a proportional part of the available energy of steam, and each of these stages also has several wheels by which the velocity is abstracted fractionally. The practical bucket velocity in a vertical turbine as a rule exceeds 430 ft. per sec. The stage pressures in the six-stage turbine, assuming equal division of work in each stage, based on 185 lb. gage steam pressure 28½ in. vacuum (30 in. barometer saturated steam) are as follows:

Stage	Stage Pressure Lb. Abs.
Throttle	200
1	90
2	40
3	15.4
4	6.1
5	2.12
6	0.75

The average available energy under the foregoing conditions is 50,000 foot pounds per stage, and average steam velocity 1780 ft. per second. The average bucket speed in a six-stage vertical turbine will be 430 ft. per second. The buckets vary in length, according to the expansion of the steam; those in the first wheel of the first stage being 1 in. in length and in the last wheel of the sixth-stage, 14¾ in. in length.

The revolving parts of the vertical turbine consist of the vertical shaft on which are placed the bucket wheels and the generator fields, the total weight of which is about 125 tons, which revolves on the end of a 16-in. shaft, upon which is arranged a step bearing which is supplied with oil at a pressure of 1000 lb. per sq. in., which is sufficient to raise the entire weight and thus the 125-ton structure revolves in a thin film of oil. The friction of the revolving part is so small that one man can turn it by hand with comparative ease when oil is supplied to the step bearing.

The new 15,000-kw. horizontal turbine operates at 1800 r.p.m. It is of the seven-stage type. The turbine wheels consist of steel disks carrying the rotating buckets on their periphery. The buckets are held in the periphery by a dove-tail shaped root which fits snugly into a channel of the same section, machined in the rim. The dove-tail channel is opened for the insertion of buckets, and this opening is afterward filled with a spacing block and closed up. After the buckets are assembled, a shroud ring is riveted to their outer ends. The function of this ring is partly to stiffen the complete row and reduce vibration, and partly to assist in retaining the steam flow in the proper path. A portion of the wheel casing can readily be removed, exposing the moving and stationary buckets and diaphragms.

In the first stage steam is introduced through nozzles covering a relatively small arc of the wheel circumference. In the low-pressure end the steam is admitted over the entire periphery, while the buckets are of considerable length. Thus the partial peripheral admission in the first stage permits correctly designed high-pressure steam passage without using exceedingly short buckets, and it is thus possible to proportion the low-pressure end in correct ratio to the high pressure end with buckets of moderate length.

FIG. 8. GENERAL VIEW OF SWITCHBOARD LOOKING NORTH; ARROW INDICATES PANEL FOR NEW GENERATOR

This type of turbine derives its energy from the expansion of steam in a series of steps or stages. The steam passes through the buckets of any one stage by velocity only, practically no expansion taking place in the stage. The actual expansion is accomplished in the nozzle passages between stages.

It is thus evident that all differences in pressure are taken up on the stationary portion of the machine and not on the rotating parts as in the reaction type. It is therefore possible to have steam tight chambers, or stages, leaving the rotating element free and independent of close running clearances. For the same reason, the rotor is in equilibrium and the necessity for balancing against end thrust is eliminated.

The oil is supplied to the bearings from a general oil distributing system. This consists of an oil pump geared to the turbine shaft by means of a worm gear, the gear having a ratio of 3 to 1, thus giving the oil pump a speed of 600 r.p.m. The oil pressure is maintained at 100 lb. for the hydraulic gear and reduced to 35 lb. for the bearings. Positive cooling is effected by pipe coils embedded in the bearing metal, through which water is circulated. A simple thrust bearing holds the rotor in a definite position and prevents axial movement.

The governor, which is of the centrifugal type, transmits its motion through a connecting rod to the valve mechanism, which in turn actuates the valves.

A simple speed limiting device is prvoided to prevent acceleration from any cause beyond a certain predetermined limit over normal speed. It consists of a ring unevenly weighted, attached to and revolving with the shaft. At normal speeds and less the unbalanced ring is held concentric with the shaft by suitable springs, but at excess speed, the centrifugal strain overcomes the spring tension, and the ring then revolves eccentrically, and trips the valve mechanism, causing the main throttle valve to close instantly thereby shutting off the steam supply.

The superiority of steam turbines over the reciprocating engine has led to its adoption for many purposes besides prime movers, and small turbines are found scattered all through Station "A." Turbine driven exciters are now being substituted for the old fashioned engine drive, and turbine driven pumps are used for the water from the condenser. Even in the boiler room it will be found that the reciprocating motion is becoming a thing of the past and the old style plunger pumps are giving place to turbine driven centrifugal pumps.

There are six exciters in the engine room, as follows: One 100-kw. motor driven, one 250-kw. motor driven, three 100-kw. turbine driven, and one 200-kw. turbine driven, the last named being installed with the new 15,000-kw. horizontal turbine.

The main switchboard consists of 38 panels in Station "A" and the new generator panel with the new type of unbalanced relays (which were installed with the new 15,000-kw. horizontal turbine) are shown at the arrow in the photo. This is the first of the unbalanced relays that have been installed in Station "A." This photo also shows the main station bus volt meter and frequency indicators near the top of the board. In the distance are the north feeder panels, and in the far end of the room can be seen the 2400-v. panels. The several standards in front of the board to the right of the photo are the exciter controls.

A special feature is the watt meters on the sub base of the generator panels, which indicate the incoming transmission load from the hydroelectric plants. By this load the generators are regulated, thus holding a certain load on the transmission lines.

Data used in the preparation of this article was furnished the writer by Mr. Delany, of the Pacific Gas & Electric Co.; Mr. Ellis, superintendent of Station "A"; Mr. Baker, chief electrician, Station 'A"; Mr. B. Fromberg, superintendent fire room, Station "A," and Mr. Pratt, of the San Francisco office of General Electric Co.

SAVING is having.—Forbes Magazine.

Penstocks and Pipe Lines

By L. W. Wyss

ACCESSORIES used in connection with a pipe line or penstock to prevent bursting due to pressure, or collapse due to vacuum, depend chiefly upon the head, contour, length and safety factor of the penstock; also whether or not apparatus is used at the power house to assure that the flow of water does not change too quickly, either during normal or abnormal operation.

Vent or surge pipes are used at most installations near the head gates. They allow the air to escape when filling a penstock and prevent the formation of vacuum when a head gate is closed or when the intake screens get blocked with ice or trash. They also prevent water hammer and high pressure caused by changes in the turbine load when the penstock intake is considerably below the dam crest.

At high installations, automatic relief valves are provided at high points in the pipe line to release the air which pockets in such places, retarding the flow of water. Automatic vacuum valves are also provided to admit air in place of a vent pipe. These two objects may be provided for in one valve. A water and pressure actuated float opens a small needle valve to release pocketed air or opens a large check valve which admits air into the penstock to relieve a vacuum.

Stand pipes or surge tanks perform about the same function as vent pipes, vacuum valves and relief valves. A simple type of surge tank is one which has ample capacity so that no provision for overflow is necessary, while another type is provided with a spillway when it is not large enough to handle the water when the turbine gates close quickly.

The differential surge tank serves the double purpose of relieving pressure surges and storing water during load changes, without allowing any material pressure increase on the turbines due to a full tank.

Air chambers may be provided at the bottom of long penstocks to regulate the penstock pressure, the air being compressed by the water. At one station these air chambers are 75 ft. high and 7 ft. in diameter, equipped with pivoted ball floats and valves, which allow free passage of water without admitting air into the penstocks. There must not be any appreciable air leakage in such a chamber, as water will displace the air and cause the chamber to lose its effectiveness as an arrester.

Steel pipe lines have one or more slip expansion joints which are usually packed with oakum or lead wool. Pipe lines are often protected from freezing, but in severe climates there are pipe lines which would freeze if the water is allowed to stop flowing very long. Surge tanks and vent pipes are often kept heated in the winter.

IN AN ADDRESS on "Engineering as Prosperity Insurance" before the Engineers' Club of Philadelphia, G. O. Smith, Director of Geological Survey, said: "My conviction is that the future of our nation will be largely what engineers make it, and the surplus that can be paid to other generations of Americans will depend upon what you engineers of today write into that endowment policy."

Efficient Organization of Power Plant Help---III

DUTIES AND RESPONSIBILITIES OF THE ENGINEER AND HIS ASSISTANTS IN INDUSTRIAL AND OFFICE BUILDING PLANTS. BY H. A. WILCOX

ORGANIZATION of power plant help in an industrial plant usually takes the form shown in the chart, Fig. 1. As we are mainly interested in the power plant end, only the chief engineer's line has been carried out to its full extent. Unlike the central station, the chief engineer is not supreme in his department. The mechanical superintendent is the head. The reason for this is as follows: The mechanical superintendent, by reason of his position, is in constant contact with the mechanical situation throughout the plant; knows what the demand for power is from hour to hour; is in intimate contact with the general superintendent and becomes acquainted with the firm's plans for the future; and can advise and direct the chief engineer as to what machines will be run and when they will run. This leaves the chief engineer free to devote his attention entirely to the running of his engines, boilers, pumps, etc. In the industrial plant of today the engines, pumps

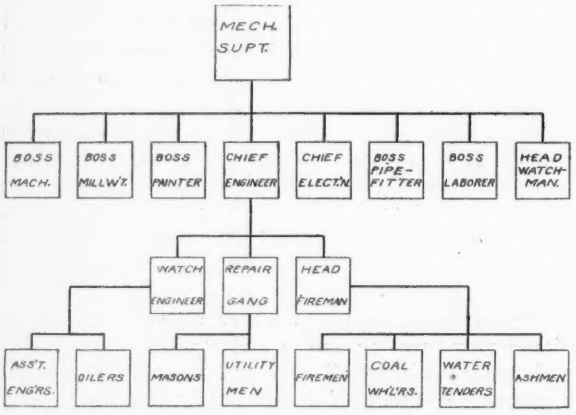


FIG. 1. DIVISION OF AUTHORITY IN THE INDUSTRIAL PLANT

and boilers are generally numerous and quite a distance apart. Therefore the chief has enough to do to keep him busy, without bothering about the larger details of the plant. Moreover, the fever of economy and conservation is fast spreading in industrial plants and the mechanical superintendent is in a good position to determine to what extent the by-products of the power plant can be utilized. These by-products comprise ashes and old brick for roads and light concrete construction, exhaust steam for heating and drying purposes, hot water for washing, etc. The mechanical superintendent, of course, must plan for future enlargements of the power plant to keep pace with what he knows of contemplated plant expansion. He must also keep his finger upon the power plant, to determine whether or not it is being operated as economically as possible and to see that all its by-products are utilized to their fullest extent. Aside from these things, the entire operation of the power end is up to the chief engineer.

The duties and responsibilities of the chief engineer are similar to those of the chief in the central station, as already outlined, with the following exceptions:

Unlike the central station man, he does not have to worry about reserve capacity, provided he keeps the mechanical superintendent well posted as to the condition of his machinery. In addition, most large industrial plants have a central station connection which can be relied upon if any of the plant machinery breaks down. In order to obtain this connection, a small part of the plant is generally driven by central station "juice." It must therefore be part of the chief's duty to know exactly how to get central station energy into any part of the plant in case the plant machinery breaks down, or vice versa. A very important department of the plant may be shut down for hours because of a break-down in the machinery driving it, if no provision is made beforehand for driving it from another available source of power. As an example, I will take an instance in the plant of which I am the mechanical superintendent.

We make part of our own electricity, buy part from the central station, and drive some of our machinery from engine-driven shafting. We have three generators, two 150-kw. and one 300-kw. They are all belt-driven from engines. They are located in the plant so that they form a triangle and are about 500 ft. apart. The central station power was so arranged that by throwing four double throw oil switches one way or the other, we could put any part of the plant on mill or central station power and we carry all we can on the mill lines. Some days the load is too heavy and we throw two, and at times three, switches upon the central station. In addition, there are a number of large motors which can be only carried on the 300-kw. machine normally. Shortly after I came we arranged to synchronize the three generators together. The two 150-kw. machines ran together very well, but the engine driving the 300-kw. machine also had a shafting load and did not synchronize with the other two very well. We therefore placed a "tie-up" switch between the 300-kw. busses and the two 150-kw. busses and left the switch open.

To a man on the ground, it looked as if we had spent $100 for a synchroscope for nothing. One day, at two minutes of twelve, just as we were shutting down for the noon hour, a flash occurred back of the switchboard of the 300-kw. machine and it went "dead" at once. At ten minutes of one we had not found the trouble and the generator would not work. We threw all four switches to the central station, put in the "tie-up" and made the two 150-kw. machines carry their own load plus that of the 300-kw. machine. They were, of course, overloaded about 50 per cent, but we knew that they were good for it an hour or so, and we expected to have the 300-kw. machine fixed in that time. We located the trouble, a broken grid in the field rheostat of the big machine, and repaired it by bridging the broken grid. Then, at 3:30 p. m., we synchronized in with the other two machines and went merrily on our way. The synchroscope on the 300-kw. machine saved a department employing 200 people just ½ hr. We would have had to shut this department down ½ hr. to get the "tie-up" switch out and the main generator in again. At an av-

erage of 30c per hour, it would have cost the department $\frac{200 \times 30c}{2} = \$30$ for the half hour, in wages alone. This is equivalent to nearly ⅓ of the $100 mentioned above. That night, walking home with the general superintendent, I spoke of the trouble with that main generator and he asked, "Did you have some trouble this afternoon? I didn't know it." I wonder what he would have said if the department had been shut down ½ hr.? Further comment is unnecessary.

The chief engineer must, of course, look after all minor repairs by means of the engineers and repair gang. He should see that all steam leaks and leaking pumps are taken care of within the power plant buildings and should report outside piping leaks so that they may be taken care of by the pipe gang. The chief should keep the mechanical superintendent well informed at all times as to the condition of the machinery under his jurisdiction and should notify him in advance as to any major repairs which will be needed in the future. He should also see that proper reports are forwarded to the mechanical superintendent so that the latter may determine at a glance the economy and efficiency of the whole power department. Finally, the chief should do all the hiring and firing in the power plant, should settle all labor difficulties arising in his department and should make recommendations from time to time on improvements and additions which he thinks are necessary, together with the *reasons and advantages* to be derived from them.

One last "tip" before leaving the chief engineer. I know of one chief who kept accurate records on the cost of operating his plant, the power developed, etc. Nobody ever saw these records, because nobody ever asked for them. One day the central station man made a very attractive proposition for furnishing the entire power for the plant. The chief was called in and asked why it wouldn't be a good thing. Under his arm was his book of records. He showed what the plant had been doing; the central station man made a graceful exit; the plant is still making the larger part of its power itself. A word to the wise is sufficient.

The watch engineers in the industrial plant occupy a position similar to those in the central station, except that their responsibility is not so large. They must always stay near their engines, as, many times, the engines carry a shafting load and a sudden stop is required if a belt breaks or somebody gets caught in the shafting. The engineer is generally notified by an alarm bell in the engine room or the plant is generally equipped with automatic engine stops. Therefore the engineer should never be out of sight or hearing of his engines. This axiom may well apply to all engineers.

The engineer should see to it that his engine, engine room and auxiliaries are always kept neat and clean and should at once call in the chief in case anything goes wrong. His main duty is to have everything running when the whistle blows in the morning and keep it going as long as the plant is in operation, avoiding, if possible, shut-downs of any kind during this time. He should keep such records as are requested by the chief and should keep all valves, pumps, etc., within the engine room properly packed. A mighty good axiom for him to follow is: "Be sure everything is ready to start in the morning, before going home at night."

In large engine rooms the engineer is given one or more assistants who look after the auxiliaries and who make very minor repairs with the assistance of the oilers.

It is the duty of the oilers to keep the machinery clean; watch all bearings and oiling system; help pack pumps, valves, etc.; clean the engine room; run errands, and make themselves generally useful.

Next on our chart comes the repair gang. This is generally composed of three or four men who, under the direct supervision of the chief, repair boiler settings; replace worn-out grates; overhaul pump and other auxiliaries; and, in fact, make all repairs possible throughout the power plant, without recourse to the force of machinists, pipers, etc., under the mechanical superintendent. When these men are called in, the power repair gang usually direct the job, as they are necessarily more familiar with the machinery. The repair gang is generally composed of men who can "fill in" around the plant. Thus if an engineer, fireman, oiler, etc., is out, a man is usually drawn from the repair gang to fill his place.

The head fireman has full charge, under the chief, of the boiler room or rooms. His main duties are to see that the steam pressure is maintained always at the proper point; keep the equipment under his charge in proper shape, notifying the chief of any extraordinary condition which may develop; take the boiler room records; and see that the men under him do their work properly. In the more modern industrial plants this man is more often a highly trained and well educated man. In this case, he of course will be expected to have due regard for economy and efficiency, as applied to the boiler room.

Under the head fireman come firemen, water tenders, ash men and coal wheelers. We have already considered their duties under our treatment of the central station, and it will be sufficient to state that their duties are similar in this case.

Thus far we have apparently been concerned with the power plant of the very large industrial concerns; however, the same reasoning applies and the same duties devolve upon the fellows in the small plants, only they are concentrated in fewer men. I have known of a number of plants where one man was the "whole thing" from chief to ash man, inclusive, but these are cases where one boiler and one engine (in the same room) comprise the whole power plant.

One last word: Remember, you fellows in the industrial plant, unfortunately most managements consider you a necessary evil, as you don't, in their judgment, produce anything they can sell, such as cloth, buttons, dyes, etc. Therefore it is up to you to do the very best you can in every way, and don't make too loud a noise doing it. Justify your existence by running your department economically and keeping it clean, all the while giving good service without annoying delays and shut-downs. The central station men have it on you there because they produce electricity for sale, but you have it on them because you can rely on the central station in case of break-downs and they have nothing but their reserve capacity (in most cases too small) to fall back upon. A break-down in their case may mean idleness and

darkness for whole cities, whereas, in your case, it affects only one plant, so you have the best of the argument.

Practically all of what has been said of the duties and responsibilities of the men in the power plants of the first two sections of this article applies with equal force to the men in the power plant of the office building, so that a chart of the organization of the force and a few words of explanation will suffice for this last but by no means unimportant section of the power plant field.

A glance at the chart, Fig. 2, shows nearly the same organization as for the first two cases. Let us now see wherein the difference lies.

What is the office building for? In large modern office buildings one finds a small city housed under one roof. The tenants hire floor space, heat, light, toilet conveniences and elevator service. With all of these, except floor space, the power plant department is intimately concerned.

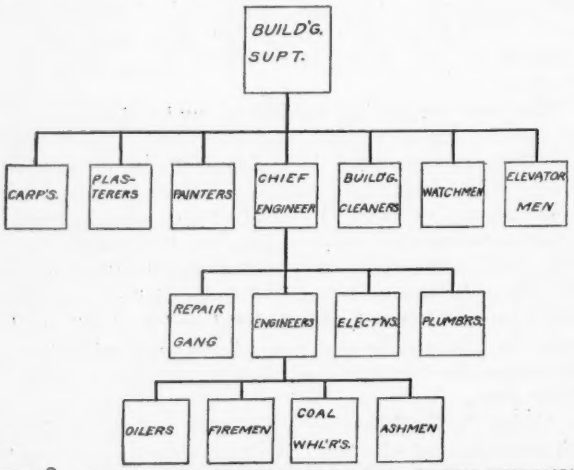


FIG. 2. DIVISION OF AUTHORITY IN THE OFFICE BUILDING PLANT

The duties of the chief engineer, in addition to those outlined in cases one and two, also include pleasing a thousand or more tenants. He must see to it that in winter the rooms are neither too hot nor too cold; in summer that the ventilating system is working at its best; that the toilets are kept in proper working condition and repair; that the lighting system is in proper order at all times; that the drinking water (if a refrigeration system is used) is at the proper temperature; and that the elevators are safe and always in good working condition. He must do all this, regardless of the fact that hundreds of careless or indifferent people may be using these conveniences all day long. In order to carry on his duties efficiently, he must make frequent personal tours of the building and machinery in order to be sure that everything is O.K. On these inspections he will run into some of the tenants, so his self-respect demands a neat appearance. If one tenant is too warm and another too cold, the chief will probably be called in and perhaps unjustly blamed for it. Regardless of this, he must never lose his temper but must use tact and courtesy. Where the central station and industrial plant chiefs have only one or two bosses, the office building chief has as many as there are tenants, notwithstanding the fact that the building superintendent is his nominal boss. In most office buildings the chief can usually rely on central station connections in case of break-down.

To accomplish all his tasks the chief has under him plumbers, electricians, engineers and the repair gang. The names of the first two define their activities and need not be considered further. The third group has practically the same duties and responsibilities as outlined under this heading in cases one and two.

The repair gang, in addition to the duties outlined for repair gangs earlier in this article, has numerous small jobs to do for the tenants which are more or less favors. If a caster comes off from an office chair, the repair gang may be asked to fix it. A desk drawer cannot be opened; the chief is called upon and he sends a member of the repair gang. Numerous other cases may be imagined. Through it all, the repair gang, electricians and plumbers must be careful of the tenants' property; must discommode him as little as possible; and must shown unvarying courtesy, regardless of treatment received.

The remainder of the force have duties and responsibilities similar to those previously outlined, and only one or two exceptions may be noted. In most office buildings, the coal and ashes are handled by automatic machinery and the services of coal wheelers and ash men are dispensed with. In most office buildings, the owners take great pride in advertising their power plants and invite prospective tenants and the public to inspect them; therefore neatness and cleanliness are prime requisites. This concludes our consideration of the office building power plant and it has been somewhat brief, due to the fact that, as previously stated, the duties and responsibilities involved are similar to those gone over in the first two cases.

We have now covered the three main fields in power plant activity and each reader must decide for himself just which portion of the article fits his own case.

In concluding, may I set forth one way in which I try to build up my own organization? When the "boys" come to me with their petty grievances and grouches on how Harry did this or Paul didn't do that or Charlie is butting in, I say: "Well, forget it all boys; just remember that it is only one big game and team-work for the good of the whole plant counts, so get out there and do your best to PULL TOGETHER."

Acknowledgment

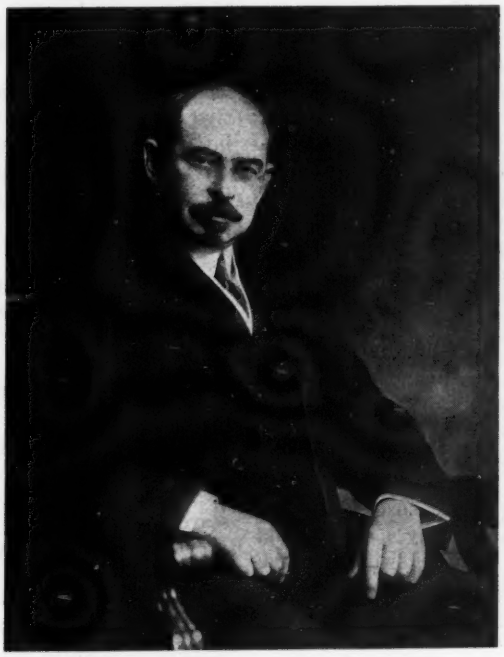
IN THE Dec. 1 and 15 issues appeared a series of two articles under the heading, "The Steam Engine Indicator Diagram." By an oversight on the part of the author, who is not on the editorial staff of this magazine, no credit was given for the source of his illustrations. Our attention has just been called to the fact that many of these were copied from the "Indicator Handbook" by Charles N. Pickworth, to whom we are glad to give due credit.

BULLETIN of American Chamber of Commerce at London states that a $15,000,000 national mining corporation has recently been formed by leading British mining finance companies, in co-operation with British capital, to develop mining properties on a large scale in different parts of the world.

E. W. RICE, JR.

REFUSED COLLEGE CAREER TO BECOME PROF. ELIHU THOMSON'S ASSISTANT. INSTRUMENTAL IN IMPORTANT ELECTRICAL DEVELOPMENTS. BY WALTER PAINTER

IN THE year 1880 Edwin Wilbur Rice, Jr., was called upon to make that momentous decision which so many young Americans have to make. He had just been graduated with first honors in his class in the Central High School of Philadelphia. Two years previous to this time he had attracted the attention of Prof. Elihu Thomson, who then taught chemistry and mechanics in the high school, by his skillful amateur work in constructing telephone and telegraph instruments, induction coils and dynamos. Then the pupil fairly won the master's heart by his success in grinding and polishing glass specula and in silvering them by a new method orally communicated to him—a rare enough feat even after seeing it done many times.



Thus it happened that young Rice had free access to the shop behind the baker's store where the earliest Thomson-Houston arc-light machines were being constructed, and thus it happened that in the summer of 1880 he was forced to choose whether he should go through college with the prospect of a distinguished career, or attach himself and his fortunes to the then infant industry of electric arc-lighting.

With that coolness of judgment which has always continued to be one of his distinguishing characteristics, Mr. Rice turned his eyes resolutely away from the attractions which a college course presented and became Prof. Thomson's assistant and confidant in the American Electric Co. at New Britain, Conn., then newly formed to manufacture arc-lighting apparatus under the Thomson-Houston patents.

While fruitful in technical development, the two years that followed were far from showing the business prosperity in the new enterprise which had been anticipated, and Mr. Rice, while acting practically as foreman of the electrical works, found time to wind armatures and otherwise to acquaint himself thoroughly with manufacturing details. Prospects grew brighter in the fall of 1882, when Messrs. H. A. Pevear, C. A. Coffin and Silas A. Barton came from Lynn to purchase a lighting plant and ended by buying a majority interest in the American Electric Co., which they transferred to Lynn and renamed the Thomson-Houston Electric Co. Then followed two or three delightful years during which Mr. Rice was permitted to devote his energies to experiment and invention, and during which his name began to be familiar in the Patent Office, often in conjunction with Prof. Thomson's, for radical improvements in the electrical art, though chiefly at this time in arc-lighting systems.

By 1885 the business acumen of C. A. Coffin, who had become associated with Messrs. Pevear and Barton on the removal of the works to Lynn, had begun to make itself felt in every direction, and the enterprise was growing with surprising rapidity. Under these circumstances the need of a superintendent of the works with an adequate technical knowledge of electricity began to be felt acutely, and Mr. Rice, though still considerably under 30 yr. of age, was asked to accept this position. If he hesitated for a moment, it was chiefly because his new field of labor would tend to break the chain of close association which had hitherto bound him to Professor Thomson.

A short trial of the new duties was sufficient to show those about Mr. Rice that he was the right man for the place and also to convince him that his new responsibilities would not necessarily impair his fertility as an inventor. Under his able and tactful management, work was systematized, production was hastened and costs were cut down. To constant-current arc-lighting were quickly added motor work, constant-potential, incandescent and railway work, while alternating-current transformer systems of lighting were developed. Of all this expansion Mr. Rice was keenly a part, growing as the work grew, keeping abreast of the world's rapid prog-

ress in electrical science, and in spite of his heavy daily task as superintendent, seldom missing an opportunity to transmute new theories into practical inventions.

From the few hundred who were employed in the Thomson-Houston factory at Lynn when Mr. Rice took charge in 1885, the number of hands had grown until 3700 were at work there in 1892, when the next great change in his career took place. The Thomson-Houston and Edison General Electric Companies were consolidated into a new concern known as the General Electric Co., with C. A. Coffin as president and Mr. Rice as technical director. To follow his career after 1892 would be to write a history of the technical department of the General Electric Co. On June 26, 1896, he was elected to the office of third vice-president of the company in charge of all its technical and manufacturing departments, eventually becoming senior vice-president and on the retirement of Mr. Coffin the unanimous choice of the directors as president.

It is worth while to look back upon the large and varied experience which Mr. Rice has had in the electrical field during the past 28 yr., during which he has been engaged, not in subordinate capacity, but in positions where his word counted with that of only nine or ten other men in the world in picking out the path of least resistance for the advance of electricity in the arts. He has seen the flexibility of the arc lamp developed to meet almost every condition of electrical circuit. The responsibility for making the crucial experiment of the West End Street Railway of Boston an electrical and mechanical success fell upon his shoulders. He has furthered the growth of long-distance electrical transmission of energy with its many difficult problems, and has followed closely the electrical and mechanical development of the polyphase motor, in which he has personally done much to insure its successful operation in commercial service. He has attacked successfully the weak point in distributing systems of polyphase currents at high voltage by the invention of an oil switch and the cellular system for separating busses and circuits now so widely used and which resulted in a switching system at once safe and simple. To him is also due the present system of alternating-current distribution and its subsequent conversion into direct current through rotary converters so largely used by Edison companies.

He has been instrumental in the development of steam turbines and has witnessed the growth of the steam turbine in large central-station systems, and their erection in sizes as large as 30,000 kw. In fact, it was he who caused the adoption of the Curtis type of turbine and its subsequent development by the General Electric Co. Owing to his faith in the tungsten lamp and its final triumph, he caused investigations to be pursued with a view of obtaining a more rugged filament, which finally resulted in the present metallic-filament tungsten lamp which has been such a boon to the electric-lighting industry and a conspicuous milestone in the development of the art.

His inventive genius is partially indicated in the statement that there have been granted to him more than 100 patents. However, while himself fertile as an inventor, Mr. Rice possesses to a conspicuous degree that valuable faculty of directing the inventive ability of others to meet the needs that are constantly arising in the industrial development of the art.

Mr. Rice is a member of the American Institute of Electrical Engineers (serving as President in 1917-1918), the Institution of Civil Engineers and the Institution of Electrical Engineers of Great Britain, a member of the Engineers' and University Clubs of New York, the University Club of Boston and the Pilgrims. After the Paris Exposition in 1900, he was created Chevalier of the Legion of Honor. In 1903, the degree of A.M. was conferred on him by Harvard University; in 1906, Union College honored him with the degree of D.Sc.; in 1918, Rensselaer Polytechnic Institute conferred the Degree of Doctor of Engineering. Mr. Rice was born at LaCrosse, Wis., May 6, 1862.

Speaking of the status of the engineer in public life, Mr. Rice has said: "I have noticed that an engineering education and training have generally developed a man's powers of observation and his desire and ability to learn. He becomes skeptical of mere theories, doubts tradition, and spurns superstitition, but he constantly searches for the truth and is not afraid of facts. 'One look is worth a thousand words,' is a proverb descriptive of an engineer's viewpoint. The engineer's training also tends to produce in him a fine blend of conservatism and radicalism. He is not afraid of a thing because it is new, and is not slavishly bound to precedent."

THE CARNEGIE CORPORATION of New York has announced its purpose to give $5,000,000 for the use of the National Academy of Sciences and the National Research Council. It is understood that a portion of the money will be used to erect in Washington a home of suitable architectural dignity for the two beneficiary organizations. The remainder will be placed in the hands of the Academy, which enjoys a federal charter, to be used as a permanent endowment for the National Research Council.

The Council is a democratic organization based upon about 40 of the great scientific and engineering societies of the country, which elect delegates to its constituent divisions. It is not supported or controlled by the government, differing in this respect from other similar organizations established since the beginning of the war in England, Italy, Japan, Canada and Australia. It intends, if possible, to achieve in a democracy and by democratic methods great scientific results.

The Council was organized in 1916 as a measure of national preparedness, and its efforts during the war were mostly confined to assisting the government in the solution of pressing war-time problems involving scientific investigation. Reorganized since the war on a peace-time footing, it is now attempting to stimulate and promote scientific research in agriculture, medicine and industry, and in every field of pure science. The war afforded a convincing demonstration of the dependence of modern nations upon scientific achievement, and nothing is more certain than that the United States will ultimately fall behind in its competition with the other great peoples of the world unless there be persistent and energetic effort expended to foster scientific discovery.

TO SHARPEN dull files, put them in a dilute solution of sulphuric acid and leave there until they are eaten deeply enough.

Water Softening in Small Plants

FALLACIES, PREJUDICES, MISINFORMATION, LACK OF KNOWLEDGE ARE GREATEST DRAWBACKS TO ECONOMY. BY F. F. VATER

DOES the small power plant need soft water for boiler feed? There can be no argument about it. When you find a plant that, using a high magnesium water which fills the boiler so full of precipitate they could run from Monday morning until Thursday noon only and then have to shut down to clean, there is a need. When you find a plant cleaning boilers every week, chipping the hard scale off the sheets, welding safe ends on the tubes every eight months, the need surely exists. When you find plants with the smoke box doors of fire tube boilers a dull red in the day time because both tubes and sheets are covered with scale, the need surely exists.

Coal loss, maintenance and repair cost are much greater in proportion in the small plant than in the large installation; in other words, the installation of a water softener in a small plant will pay a larger percentage of dividends than is paid in the large plant. Tons and tons of coal are wasted annually. Large sums of money, in the aggregate, are spent on repairs. Sunday after Sunday, engineers are hard at work cleaning dirty boilers, repacking pumps, because of cut cylinders and piston rods, and repacking valve stems on the steam mains.

WHY CONDITIONS ARE NOT CHANGED

THE REASONS are many and among them are the following:

1. Lack of knowledge of what dividends a softener will pay.

2. Owners have seen instances of, or had troubles where softeners were installed, due partly to improper operation and partly to faulty design or (just as bad) to faulty application.

3. Sometimes it is a lack of capital on the part of the plant owner.

4. There also is the man who, while having ample means, hates to part with it and who, in that strenuous effort to pinch a little copper off the penny, prefers to spend a little sum in trying out any cheap "cure-all" anybody will suggest to him, from the latest compound through kerosene oil, black oil, tannic acid, sodium silicate, graphite, down to turning his boiler into a kitchen kettle and boiling potato peelings to stop the scale.

5. There is the unfortunate man who paid good money to that genius down the road 30 miles, only to find that lemons are very high and that the genius, his engineer and nobody else can make the device work.

6. Some of the time there is no softener at work because the engineer in charge of the plant does not realize that his employer is thinking in dollars and cents and that to hold his attention you must show him in dollars and cents what his loss is under present conditions and show him what a softener would cost; what the interest and depreciation is; what the cost of chemical, labor and maintenance will be, so that he can *see* the profit his investment will bring him. In other words, you must show him that a water softener is a better dividend payer than bank stock.

7. There is a class of men who are optimistic and, although they have just completed the job of putting four new sheets in three boilers, do not believe it will happen again, although they have been through the same mill a dozen times. He is a hard nut to crack and is the kind who believes economy is all "tommy rot," being an invention of the devil to separate him from some of his money. He will tell you with a grin that if he bought all the saving devices offered him, he could run his plant without coal, showing at once that he did not have intelligence enough to judge between a device of merit and a fake pure and simple.

8. Unfortunately there are a few engineers who believe in compounds and are quite fond of the five-dollar gold piece they find in the bottom of the compound barrel.

WHAT IS THE ANSWER?

WAKE UP, operating engineers, you have been asleep too long. Get rid of your old nonsensical prejudices. Because about 3000 prejudiced salesmen in the United States tell you caustic soda or soda ash will pit your tubes and sheets or start your boiler leaking, does not make it true. That same salesman is selling you a substance containing caustic soda or soda ash. He may not know it and you may not see it, but it is there. Get your employer to get a chemist to analyze it and know for yourself. It does not cost much to get a determination on these two points. What else may be in the compound need not interest you. The base of any compounds that are of any benefit anywhere is soda ash or caustic soda.

If your employer will not spend the money, find out in other ways. Go to some plant where a softener is in service using a soda ash solution tank made of steel and examine it, bearing in mind that this solution tank is handling a solution one hundred times stronger than you could possibly use in a boiler. Know that more than a million boiler horsepower in this country are feeding soda ash every hour of every day and have been for 10 yr. past. Know also that whenever and wherever lime and soda ash are brought together in a solution in a ratio of 7/10 of lime to one of soda ash, the solution ceases to be lime and soda ash and becomes caustic soda which you fear so much.

I say again, operating engineers in small as well as large plants, wake up! Learn the philosophy of softening water; learn the chemical terms and their meaning. They can't hurt you. Learn why a soap solution is a volumetric measure of the hardness (or scale-making matter) a water contains. Learn what causticity is. Learn what alkalinity is. Learn their relation to each other and what effect they have on the water after it reaches the boiler. Ca CO_3 may look mysterious, but its meaning is very simple, viz:—lime carbonate; if very pure, it is marble. Learn why lime carbonate or marble dissolves in water; it is simple; it is not hard and it will be of much use to you. Learn especially about water softening because it is the coal saver, the economizer,

and at the rate coal is wasted today, there will be none left for your grandson to fire.

Realize the nobility of your calling. Realize that you are not simply an engineer for your employer but you are conservators to the public. Realize that your job is not merely to do the day's work, but that it is to know. Know not merely how to oil the engine and keep her turning over, but also know the principles governing her design. Be her doctor. Recognize the symptoms of sickness and know how to cure it, and know this not only of your engine but of the boiler, stoker, pump, heater, water softener and the many auxiliaries coming under your care.

Is it not your job to show your employer that water softeners pay? Can you do it if you do not know anything about a water softener? Is it not your job to show your employer that if the water softener failed, it was due to faulty design or faulty operation? Do you think that you could find a manufacturer of water softeners who would give your employer (with limited means) time for a softener to earn at least partially its cost if that manfacturer *knew* you would operate the apparatus correctly and make the savings? Is it not your job to know how to handle the man you are working for and get from him money to install economizing devices when you know they will pay? In other words, is it not your job to work for posterity as well as your employer, and how can you cover the broad field if you have little knowledge?

The first answer to the seven reasons is, I am sure, a better posted body of operating engineers. Engineers and owners should know just enough geology to know that there are two rocks burned into lime. The names of these two rocks are calcite and dolomite. Oftentimes lime is burned from rock composed of both calcite and dolomite. Calcium is calcite. Magnesium is dolomite. A lime burned from a dolomite rock or a rock composed of calcite and dolomite is worthless in water softening. You must use a lime burned from a calcite rock. When rock is burned, the carbonic acid is driven off with heat. It then becomes the oxide. It is used to absorb the carbonic acid in the water, which makes the rock soluble. After being used in a softening process and absorbing carbonic acid, it reverts to its original form, except that it is in fine particles. Magnesium lime will not absorb this carbonic acid. Calcium will. Therefore, use calcite lime. Stick a pin into this and remember it.

There is another answer to the seven reasons why water softeners are not more largely used in small plants; this answer lies with the manufacturers of water softeners. Application versus misapplication is the answer.

It is unfortunately true that the public have partially (wholly for some of them) paid for the education of the manufacturer. He has attempted where he did not know. It is hardly to be expected that the public can discriminate between a proper and improper application. This is the manufacturer's job. He either does not know the limitations of his apparatus or knowingly misleads, and neither is excusable. The time has come when the manufacturer must analyze his product from an engineering standpoint rather than one wholly of profit. He must cultivate his nerve up to the point of refusing to sell a plant if the conditions are impossible. The apparatus for softening water that has no limitations has not yet been produced. It is up to you, Mr. Manufacturer, to learn the limitations of your machine and, knowing this, "come across clean" and refuse to misapply them.

The higher the boiler pressure and the greater the percentage of overload, the purer the water must be. Not only must it be softened to a low hardness content, but its alkalinity and causticity also must be low. To the softener manufacturer, the engineer and the public, I say stick a pin in here. Keep to the middle of the road, Mr. Public, and consider well before you attempt 300 lb. pressure and 300 per cent of rating. Its cost will be greater than the dividends.

The other answer is to educate the power plant owner. This is as large a contract as is posting the operating engineer. Usually he is a busy man; he does not read much but the daily paper and his class periodical. The class periodical is generally very technical or quite gossipy and does not attempt much in the broad educational way. The engineering journals are doing nobly; but if one of these reaches his desk, it goes to the engineer.

There is not enough specific information published about water softening, possibly; not theoretical data, but actual cases where savings have been made. I have in mind a case that came under my observation and it may be of interest. The results given are not theoretical; were not obtained by test runs; but are a comparison of coal burned with the tonnage output for a period of four months. The weight of coal was based wholly upon the bills paid. Operation without a softener for the months of August, September, October and November, 74 tons a day. Operation with a softener for the same period, 38 tons a day, saving 36 tons a day.

Coal was not the only saving. The tube loss using raw water was 125 a year—using soft water, none. Labor saving in the boiler room, two men—tonnage output of product, the same. It seems too good to be true; nevertheless it is absolutely true.

These results were not obtained where abnormally hard water was used, neither was the pressure nor the overload percentage high. The water contained total solids about 20 grains, incrusting solids about 17 grains —just such a water as you are using, Mr. Man, who tell us you have no trouble. If the results cited do not mean trouble, will you please define the word?

The railroads of this country are largely buyers of more or less makeshift water softening equipment. Their plants are far from being models. Nevertheless they have kept records for years and know that one pound of scale forming matter removed from the locomotive supply means a saving of 11c. Then using a 21-grain water, the saving will be 33 cents for every 1000 gal. of water evaporated. Nor is this all; the life of a locomotive firebox was increased from 2 to 14 yr.

Another answer to the seven reasons lies in some system of cost accounting. Ask the owner of a small plant how many pounds of water he evaporates per pound of coal and he is lost. He doesn't know what the coal cost of shutting a boiler down to clean means. He doesn't know how thick the scale is, but doesn't think there is much of it, as he has a good engineer. He doesn't know how much overtime that good engineer puts in trying hard to keep the boilers clean.

If he kept any account at all, it is probably called

power costs. It is not power costs in anything but a lump sum. It is doubtful whether he could analyze it; and more than doubtful whether he does more than write it off at the end of the year and forget it.

Fuel Administration Results

Be your opinion of the Fuel Administration during the war what it may, the conservation department of this administration did more good work along educational lines as to how to stop coal waste than any dozen other agencies this country ever saw. They took the position that economy was vitally necessary and that your plant must be operated economically or you must shut down and buy power from that company which did produce it economically. Economy is just as vitally necessary now. Millions of tons of coal were saved, and every ton conserved was a direct addition to the nation's wealth.

It is your duty, Mr. Small Plant Owner, to continue the good work, even though the pressure is released. Waste is a crime. Don't be a criminal. Save! Not only because in so doing you are adding to your own wealth, but because you are adding to the wealth and comfort of generations unborn.

Water-Tube Boiler for Wood Ships*

Part I—Description of Boiler and Results of Evaporation Tests. By F. W. Dean

In 1917 the Emergency Fleet Corporation embarked upon a program of building a great fleet of wood ships for the purpose of quickly meeting a great emergency. Wood was selected not only for accelerating delivery but for reducing the demand for steel which was needed for steel merchant and naval vessels.

At first it was intended to build 1000 wood ships of 3500 tons deadweight capacity each, and each ship would require two boilers containing about 2500 sq. ft. of heating surface each. The program for 1000 wood ships was considerably reduced and instead 2000 boilers, 1352 of the water-tube type were ordered.

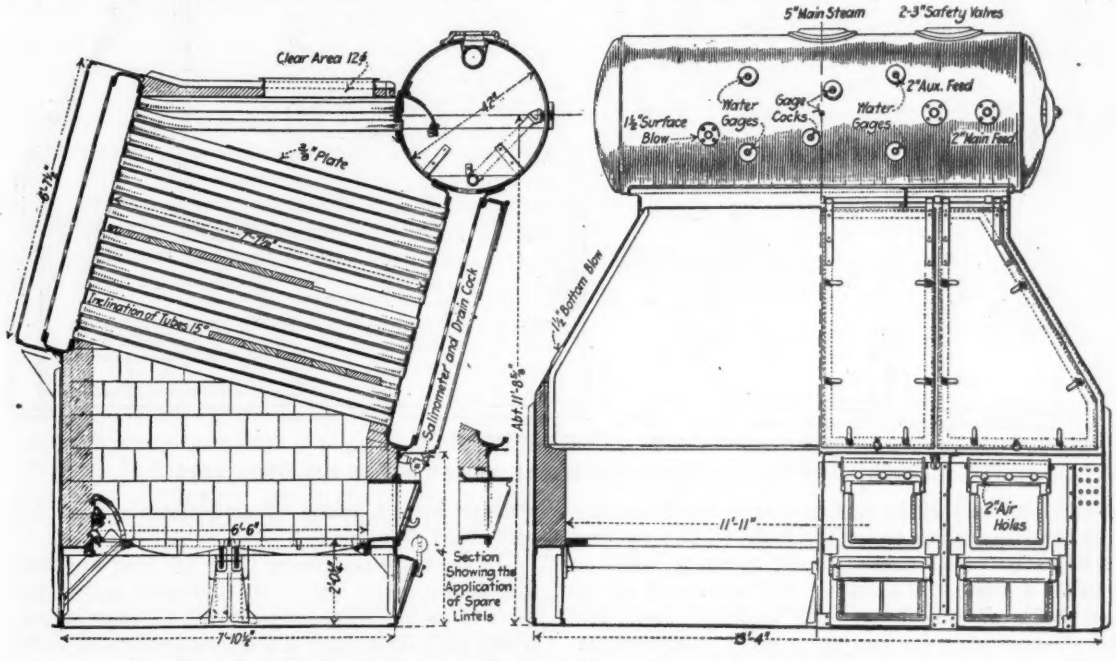


FIG. 1. THREE-PASS STANDARD WATER-TUBE MARINE BOILER FOR WOOD SHIPS

Description of the Boiler

The boiler as first designed is shown in Fig. 1, and as later modified in Fig. 2. It consists of two headers, each composed of two plates, known as tube and handhole plates, connected at the edges by channel-shaped part of the back header with the drum and serve to conduct the steam to it.

The drum was made with the longitudinal joint where the circulating tubes enter, an inside and an outside strap being located here. The tubes pass through the shell and both straps, but the holes in the shell are larger than the tubes and the expanding occurs only in the straps. The drum is reinforced at the bottom by means of an inside strap in order to make up for the plate section cut away by the holes referred to.

The tubes are seamless hot-rolled steel. The baffles are of the longitudinal type, of which the first boiler

*From paper presented before the American Society of Mechanical Engineers.

tested had three, forming three passes as shown in Fig. 1. After some testing it was decided that it was best to place the lowest baffle on the lowest row of tubes in order to render the second and third rows of tubes more active as heating surface. In the first design these tubes did little good except such portion of them as extended across the first pass. When this change was being made it was seen that there was room for four passes and accordingly four baffles were inserted. This rendered the boiler somewhat more efficient, especially at the higher powers, and made the efficiency curve flatter than in the case of three passes.

In the three-pass boiler the upper baffle was of steel plate and the others of tiles, but in the four-pass boiler the two upper baffles were of steel and the indications are that the others might be of steel if the tubes were sufficiently near together to touch the baffles on both sides and thus conduct the heat from them into the water. In the four-pass boiler tested the baffle next to the lowest was made of steel, and although it merely rested on the tubes it stood the service. The outer end of the lowest baffle of this boiler was made of steel, and although it merely rested on the tubes it stood the service. The outer end of the lowest baffle of this boiler was made of steel, and although it was in contact with tubes on the bottom only it stood the service fairly well. Experience with steel baffles in a Foster boiler tested at Burlington, Iowa, showed that they stood so well that they were adopted in all positions in this boiler. By using steel baffles in the four-pass boiler, 34 more tubes can be put in. The four-pass boiler is shown in Fig. 2.

In the drum of the four-pass boiler there is the usual deflector plate which prevents the steam, as it comes through the circulating tubes, from passing across the drum and compels it to pass to the ends. This deflector was removed for a time and no difference in the behavior of the boiler could be observed except that the water as it appeared in the glasses was livelier. In a seaway other advantages might appear.

In the top of the drum a perforated drypipe is used having eighty-eight ⅜-in. holes. This is a rather small area and it proved to have an important effect in separating moisture from the steam. This was determined by testing the boiler both with and without the drypipe. The reduction in the pressure of the steam in passing from the drum to the steam nozzle was determined by a mercury manometer. At ordinary rates of working the loss in pressure amounted to little, but when forcing it amounted occasionally for short periods to 6 or 8 in. of mercury.

The boilers are equipped with bottom and surface blows, a duplex safety valve, two water glasses, a set of three gage cocks, main and auxiliary feeds, a salinometer cock, a basket of zinc plates and an internal perforated feedpipe.

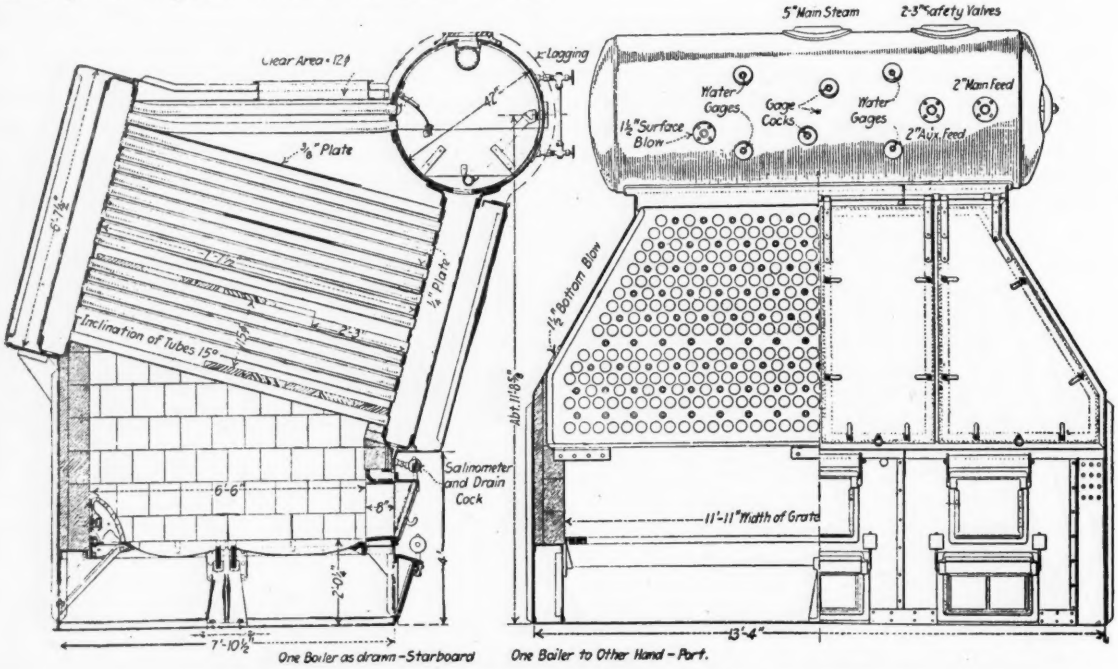


FIG. 2. FOUR-PASS STANDARD WATER-TUBE MARINE BOILER FOR WOOD SHIPS

In the three-pass boiler there are four fire doors and four ashpit doors, but in the four-pass boiler there are three of each. These doors are of the in-swinging type. Above each door there is a hollow perforated lintel with air freely entering through holes in the casing, and on the sides of the doors there are perforated jambs with air supplies from the outside. All of these air openings are not only useful in protecting the parts from burning, but promote economy, for it is found that none too much air enters the furnace through them.

The grates are of the fixed type of double bars in two lengths, and have ½-in. air and ½-in. iron spaces.

Across the back end of the furnace there is a cast-iron bridge wall with narrow air spaces which saved nearly 2 per cent of coal, perceptibly diminished smoke, improved the gas analyses, saved the back brickwork and reduced the time and labor of cleaning the fires nearly 50 per cent.

Dimensions of Boiler

The following are the leading dimensions of the boiler:

Width of casing at floor level	13 ft. 4 in.
Length of casing at floor level	7 ft. 10½ in.
Height of center of drum above floor	11 ft. 8⅝ in.
Thickness of header plates	11/16 in.
Width of water spaces of headers	8 in.
Outside diameter of tubes	3 in.
Exposed length of tubes between headers	7 ft. 7½ in.
Number of tubes between headers	388
Number of tubes between rear header and drum	21
Inside diameter of drum	42 in.
Thickness of drum plates	⅝ in.
Width of furnace	12 ft.
Depth of furnace	6½ ft.
Height of furnace at center	3 ft. 8 in.
Firing doors	15 in. by 18 in.
Width of grate	11 ft. 11 in.
Depth of grate without bridge wall	6 ft. 6 in.
Depth of grate with bridge wall	5 ft. 8 in.
Grate area without bridge wall	77½ sq. ft.
Grate area with bridge wall	67½ sq. ft.
Heating surface fire sides	2518 sq. ft.
Thickness of brick lining	8½ in.

In the beginning it was decided to use Georges Creek Cumberland coal from the Big View vein on all tests in order to have a standard coal of good and uniform quality, low volatile content, and high-fusing clinker.

It was also decided to make tests with fixed grates, shaking grates, firebox without a bridge wall, with the iron bridge wall already mentioned, a brick bridge wall covering the same area as the other, and several kinds of oil burners, using Mexican oil. Mexican oil was selected because that is the oil that will be used chiefly in the future.

The three-pass boiler was erected with the baffles in the positions and of the lengths in the original drawing, but the first test showed that they were not sufficiently long. Several of the earlier tests were made with the grate of the full size, that is to say, without the iron or the brick bridge wall. By the addition of the iron bridge wall, admitting air around the fire doors, lengthening and otherwise changing the baffles, and studying the method of firing, the efficiency of the three-pass boiler was raised from about 60 per cent to about 71 per cent based upon dry coal, and to about 73 per cent based upon combustible. The efficiency of the four-pass boiler was about 72½ per cent based on dry coal, and based upon combustible exceeded 74 per cent on two tests. These tests were made when firing by hand, but when using the "Type E" stoker higher efficiencies were obtained.

Results of Tests

The accompanying table shows the general results of the tests of the boilers when stoker firing.

While it was intended to test the boiler at the marine rating in general, which is to evaporate 6 lb. of water per sq. ft. of heating surface per hr., other rates were used, especially with the four-pass boiler. On Dec. 18, 1918, the four-pass boiler was worked at 131 per cent of marine rating and 229 per cent of land rating. Even at this high rate the efficiency was about 71 per cent, and but little below that of lower rates. With the stokers the boiler was operated at 162 per cent of marine rating and 282 per cent of land rating. At this rate the evaporation was 9.72 lb. per sq. ft. of heating surface per hr. from and at 212 deg., and the efficiency was 72.3 per cent based upon combustible. Based upon the total area of grate for hand firing the coal consumption was at the rate of 29.6 lb. per sq. ft. of grate per hr.

RESULTS OF TESTS OF FOUR-PASS BOILER EQUIPPED WITH TWO UNDERFEED STOKERS

1 Date, 1919	April 8	April 9	April 13	April 12
2 Duration, hr.	24	24	22	24
Dimensions and Proportions				
3 Grate area, sq. ft.	77.50	77.50	77.50	77.50
4 Heating surface, sq. ft.	2500	2500	2500	2500
5 Ratio grate area to heating surface	32.26	32.26	32.26	32.26
Average Pressures				
6 Gage pressure, lb.	199 00	199.00	197.00	198.40
7 Atmospheric pressure, lb.	14.51	14.51	14 50	14.44
8 Absolute pressure, lb.	213.51	213 51	211.50	212.84
9 Draft between damper and boiler, in.	0.35	0.85	1.40	1.43
Average Temperatures				
10 External air, deg. fahr.	47	53	50	44
11 Fire room, deg. fahr.	61	68	63	62
12 Feed water, deg. fahr.	66	67	66	63.40
13 Escaping gases, deg. fahr.	535	591	618	659
Fuel				
14 Moist coal consumed per hour, lb.	1189	1614	2000	2392
15 Moisture in coal, per cent	2 92	2.82	3 35	4.14
16 Dry coal consumed per hour, lb.	1155	1568	1933	2293
17 Dry refuse per hour, lb.	126	160	184	214
18 Dry refuse in per cent	10.90	10.20	9.50	9 30
19 Combustible consumed per hour, lb.	1029	1408	1749	2079
Quality of Steam				
20 Moisture in steam, per cent	0.75	0.75	0.85	1.02
Heat Value of Coal and Efficiency				
21 Heat value of one pound of dry coal, B.t.u.	14040	14342	14234	14404
22 Effic ency of boiler based on dry coal, per cent	79.20	75.00	72.50	71.40
23 Efficiency of boiler based on combustible, per cent	80.20	76.50	72.90	72.50
Water				
24 Water supplied to boiler per hour, lb.	11124	14588	17253	20390
25 Dry steam generated per hour, lb.	11041	14479	17106	20182
26 Factor of evaporation	1.20	1.20	1.20	1.204
27 Equivalent evaporation from and at 212 deg. per hour, lb.	13249	17375	20527	24299
Evaporative Performance				
28 Water evaporated per pound of dry coal, lb.	9.55	9.23	8.87	8 80
29 Equivalent from and at 212 deg., lb.	11 47	11.08	10.62	10.60
30 Water evaporated per pound of combustible, lb.	10.85	10.21	9.80	9.66
31 Equivalent from and at 212 deg., lb.	12.90	12.34	11.70	11.68
Rate of Combustion				
32 Dry coal burned per sq. ft. grate per hour, lb.	14.90	20.23	23.80	29.60
33 Dry coal burned per sq. ft. heating surface per hr., lb.	0.46	0.62	0.77	0.92
Rate of Evaporation				
34 Water evap. from and at 212 deg. per sq. ft. h. s. per hr., lb.	5.30	6.95	8.21	9.72
35 Water evap. from and at 212 deg. per sq. ft. grate per hr., lb.	170.90	234.20	264.00	313.60
Power of Boiler				
36 Commercial horse power for land use, hp.	384	504	595	704
37 Excess above commercial rating of 250 hp., per cent.	54	102	138	182
38 Marine rating in water evap. per hr. from and at 212 deg., lb.	15000	15000	15000	5000
39 Equiv. commercial hp. of marine rating, hp.	435	435	435	435
40 Excess above or below marine rating, per. cent.	12 below	16 above	37 above	62 above

The coal consumption per sq. ft. of heating surface per hr. on this test was 0.92 lb. The test of April 8 shows a very high efficiency, but this is open to suspicion because the heat balance did not work out quite properly, due, it is thought, to an error in the coal weight of one hour.

It will be observed that three of the tests given in the table were of 24 hr. duration each, and one of 22 hr.

The conclusion arrived at is that the boiler is of

excellent efficiency and that the four-pass boiler is well adapted to overloads. This is due to its having four passes. The only defect of the four-pass boiler is, as might be expected, that there is considerable absorption of draft in the passes, and the greatest loss was in the third pass from the bottom. The third baffle was lowered one tube, but the great loss continued, and it was then restored to its former position.

Among the experiments tried with this boiler were those to determine whether the number of circulating tubes and the number of holes in the bottom of the drum connecting its water space to that of the front header were excessive. Half of them, together and separately, were closed, but no effect could be observed. The conclusion was that an unnecessary number of such tubes and openings are used in this type of boiler, and by reducing them the drum will be made a safer structure.

The quality of the steam was most satisfactory when the water was carried at a proper level, and it was necessary to carry it near the top of the glass before the limit of a throttling calorimeter was reached. The quality of the steam is given in all of the tables.

(To be continued.)

A New Type of Vacuum Dashpot

By F. B. Miller

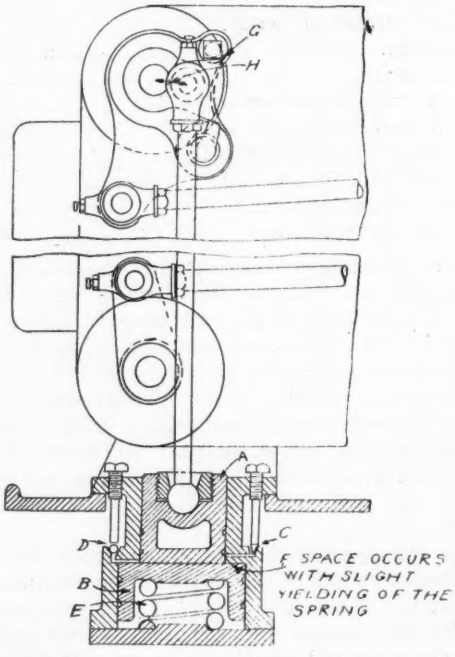
A NEW type of vacuum dashpot for Corliss valves has been designed for the operation of Corliss engines at higher speeds, and steam pressure, in connection with long range cutoff and close regulation.

Advantages gained with such conditions are prominent—for example, in the operation of a direct connected generator for lighting, and operating elevators, in an office building. High speed, high steam pressure and long range cutoff reduce the size of the generator and engines, also reducing floor spaces required; therefore the first cost is considerably less. Close regulation is necessary to avoid flickering of the lights, due to the fluctuation in load caused by the operation of the elevators. Efficiency is increased with the high compression, which is a characteristic of a high speed engine.

A brief synopsis of the construction and action is as follows: When the plunger, A, is released, the air that is taken in through the air valve, C, is discharged through the check valve, D, which is adjustable. The piston, B, will take the thrust noiselessly and without rebound, due to the combination of an air cushion and the slight yielding of the spring, E, which is not more than 1/16 in. at the maximum. The spring is of a heavy durable type and not subject to great changes. It is obvious that all the air cannot escape through the check valve, D, instantly, therefore a portion of the air is compressed in the space, F, caused by slight yielding of the spring. This air forms a cushion for reseating the piston, B, and at the same time the air is given a period in which to escape. Disposing of all the air under the plunger means practically a perfect vacuum, or the maximum atmospheric pressure on the face of the plunger regardless as to whether the lift is 1/16-in. or the maximum. Should there be, by reason of poor judgment, a slight space between the piston and the plunger, this is mechanically eliminated by having a type of valve gear with the clearance, C, reduced to a minimum (about 1/64 in.). This small amount of clearance is only possible by having the spring, which serves as a preventive against breaking any member of the valve gear. Therefore it is not necessary to make allowance for the expansion of the engine cylinder, dirt, oil or poor adjustment.

With a high-speed engine having the long range gear cutting off at the maximum, the period of cutoff is very short; this is accomplished by reducing the radius, H, to the minimum, thereby shortening the lift of the dashpot plunger, which means a shorter period of time required for complete cutoff.

The long range valve gear cutting off at the minimum, the lift of the plunger is slight, but, having the maximum atmospheric pressure on the face of the plunger regardless of the lift, the friction on the steam valves under high steam pressure is overcome.



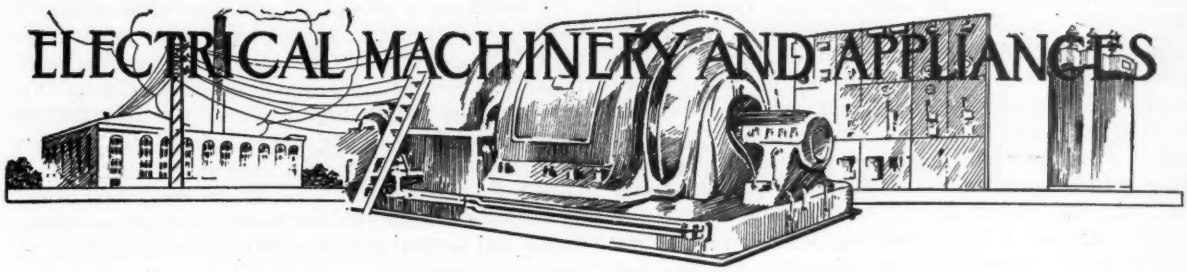
CROSS SECTION THROUGH VACUUM DASHPOT

The complete cutoff of the steam takes place more rapidly and positively, regardless of the variation of the load on the engine, thereby avoiding leaky valves and poor regulation.

It is also evident that the positive seating of the vacuum pot plunger will permit a smaller lap on the steam valves, with the result that less angular advance is needed, which means a greater range of cutoff under control of the governor and a corresponding increase in the number of horsepower.

Howard Elliott, president of Northern Pacific Railroad, stated at St. Paul, Jan. 2, that $3,000,000,000 must be spent by U. S. railroads "within the next few years," to provide first-class passenger and freight facilities.

"The man who goes into battle fainthearted is already half beaten. Fear of taking a chance often keeps a valuable man in the ruck."



Power Factors Financially Considered

SAVINGS TO BE EFFECTED BY THE PROPER USE OF THE RIGHT EQUIPMENT. BY F. C. DEWEESE

THERE have appeared in the technical press the last year several good articles on the subject of "power factor," but not very much has been written that gets right down to the dollars-and-cents proposition and brings out the facts in such a way that its benefit can be understood by the consumer as well as by the engineer.

In what follows will be found worked out an example showing what may be accomplished by the proper design of equipment, or, in other words, the installation of the proper equipment. This problem will show the saving to be made in first-cost and also the saving to be made from one year's operation of a transmission line, designed, in one case, to handle a given load at 80 per cent power factor, and in the other case, to handle the same load at 90 per cent power factor.

Assume a three-phase line, to transmit 5000 kw. a distance of 10 mi., generating voltage 33,000, frequency 25 cycles, wires spaced 48 in., and a permissible line loss of 10 per cent of the generated power. Regulation of 10 per cent is assumed.

The voltage to neutral at generating station is equal to 33,000 divided by $\sqrt{3}$ or 19,050 v. And at 10 per cent regulation the voltage at receiver equals 19,050 times 0.90 or 17,145 v.

Current per wire, at 90 per cent power factor, equals

$$\frac{5{,}000{,}000}{3 \times 17{,}145 \times 0.90} = 108 \text{ amp.}$$

Current per wire, at 80 per cent power factor, equals

$$\frac{5{,}000{,}000}{3 \times 17{,}145 \times 0.80} = 121 \text{ amp.}$$

Loss per wire equals

$$\frac{5000}{3} \times \frac{0.10}{0.90} = 185 \text{ kw.}$$

Resistance per wire, at 90 per cent power factor, equals

$$\frac{185{,}000}{(108)^2} = 16 \text{ ohms or } 1.6 \text{ ohms per mile.}$$

Resistance per wire, at 80 per cent power factor, equals

$$\frac{185{,}000}{(121)^2} = 12.6 \text{ ohms or } 1.26 \text{ ohms per mile.}$$

The next largest size commercial wire having a resistance of 1.6 ohms per mile is number 4 B. & S. gage, which has a resistance of 1.51 ohms per mile and a weight of 667 lb. per mile.

The next largest size commercial wire having a resistance of 1.26 ohms per mile is number 3 B. & S. gage, which has a resistance of 1.04 ohms per mile and a weight of 841 lb. per mile.

The difference in weight is equal to 841 minus 667 or 174 lb. and at the prevailing price of 23 cents for copper this would amount to $0.23 \times 174 \times 10 \times 3$ or $1200. At 6 per cent interest, this would amount to a saving on copper alone of 1200×1.06 or $1272.

It will now be shown how the needed increase in power factor may be obtained.

Assume that the consumer has a 600-kw. mechanical load of such character that it could be handled with a

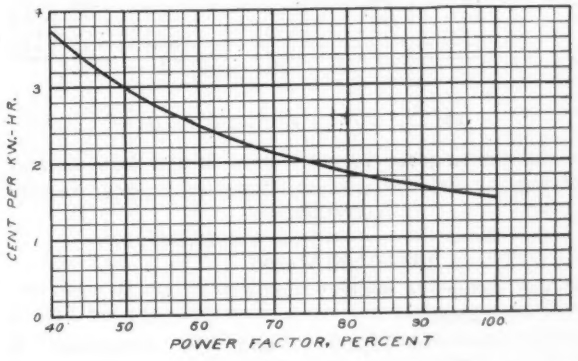


FIG. 1. CURVE OF RATES THAT VARY INVERSELY AS THE POWER FACTOR

synchronous motor, the motor at the same time to have sufficient condenser capacity to give him the needed power factor correction.

By a study of the accompanying power factor diagram it will be seen that it will require a 1500-kv.a. synchronous motor.

In the first place, he has a 5000-kw. load which is operating at 80 per cent power factor and is equal to 6250 kv.a., and by operating his synchronous motor at 40 per cent power factor "leading," he will be able to handle 600 kw. and at the same time give him 1375 kv.a. reactive power, which will increase his power factor to 90 per cent and reduce the kv.a. from 6250 to 5535.

By referring to the vector diagram, Fig. 2, it will be

seen that the vertical line drawn to scale represents the 600-kw. mechanical load, and the horizontal line represents the 1375 leading kv.a., and by connecting this point shows that the vector intersects the lagging power factor circle at approximately 90 per cent, and by calculation is between 90 and 91 per cent power factor. Thus you can see they are still handling the 5000-kw. load and have reduced their kv.a. 715, which at 80 per cent power factor is equal to 572 kw.

We assumed a 10 per cent regulation and will now check this by calculation to see whether or not the calculated value checks with our assumption. We will first have to calculate the value of the receiver voltage and from this value check our regulation.

The receiver voltage is determined by the following formula:

$$I = \frac{W}{1.73 \times Er \times \cos A}$$

Where I is load current in amperes; W, load in watts; Er, line voltage at receiver, and $\cos A$, power factor.

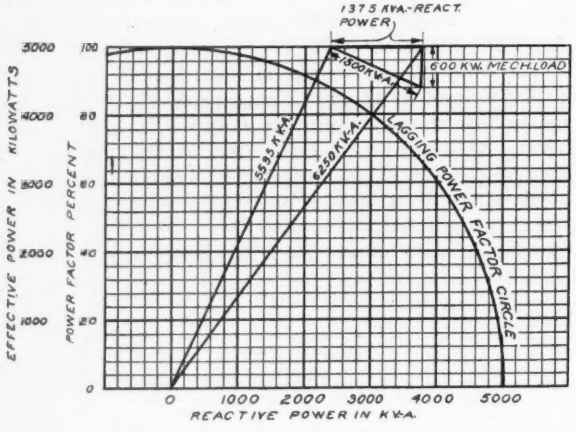


FIG. 2. POWER FACTOR DIAGRAM

Substituting the known values in the formula and solving for Er, we have, at 90 per cent power factor:

$$Er = \frac{5{,}000{,}000}{108 \times 1.73 \times 0.90} = 29{,}800 \text{ v.}$$

The voltage to neutral equals

$$\frac{29{,}800}{1.73} = 17{,}200 \text{ v.,}$$

and the regulation is equal to

$$\frac{19{,}050 - 17{,}200}{17{,}200} = 10.3 \text{ per cent.}$$

The regulation, voltage, etc., at 80 per cent power factor checks well within the limit.

We will now take up the consumer's side of the question and see how much he will be required to spend in order to maintain the power factor of his load at 90 per cent instead of at 80 per cent and in order to do this we will have to delve slightly into the subject of rates.

This is a proposition delicate to handle with all fairness to the parties concerned, but it seems that a rate that would vary inversely as the power factor, would be fair. Anyway the calculations will be based on this assumption.

I would say a rate of 1.5 cents per kilowatt-hour at unity power factor, then at 90 per cent power factor the rate would be 1.6666 cents, and at 80 per cent power factor it would be 1.875 cents per kilowatt-hour. The accompanying curve, Fig. 1, shows the rate for any power factor from 40 per cent to 100 per cent inclusive.

If this consumer requires 5000 kw. for 2500 hr. per year, his power bill will be, at 90 per cent, $2500 \times 5000 \times 0.016{,}666 = \$208{,}250$, and his bill at 80 per cent power factor will be $2500 \times 5000 \times 0.018{,}75 = \$234{,}375$, a difference of $26,125.

If his power factor should drop from 80 per cent to 70 per cent the difference would be $33,500, so you can see that it does not follow a straight line.

If the central station would establish its rate on a basis of 90 per cent power factor, or possibly 85 per cent, all saving made by reason of increasing his power factor above these points could be termed as a premium, and the consumer would make every effort to keep the power factor of his load as high as possible.

Estimating the efficiency of the 1500 kv.a. synchronous motor pulling a 600 kw. mechanical load, at 65 per cent and that of an 800 hp. induction motor running fully loaded at 90 per cent, the difference in operating cost for the year would be $7225, which would leave him a saving on operating cost of, 26,125 — 7225 or $18,900 per year.

The difference in the cost of transformers in this case would be approximately $1500. A 1500-kv.a. synchronous motor, with direct-connected exciter will be approximately $18,000, and that for an 800-hp. induction motor approximately $4500, or, a difference of 18,000 — 4500, or $13,500. Then the total expenditure for equipment in order to give the increase in power factor, will be 1500 + 13,500, or $15,000, and allowing 10 per cent, to cover interest and depreciation, will be $15{,}000 \times 1.10$ or $16,500. This will still leave a saving for the first year of $18,900 — 16,500, or $2400 and as the life of his plant will range over a number of years, it can readily be seen that he would be justified in spending quite a sum of money.

For each year thereafter his interest charges will decrease as the depreciated value of his synchronous motor and additional transformer equipment.

The kilowatt load was seen to be reduced 572 kw., which is equivalent to a decreased generating station equipment of this amount.

We will assume that it costs 1 cent per kilowatt-hour to generate and transmit power over a 10 mi. line; then the saving from this source will be $572 \times 2500 \times 0.01$, or $14,300, which with copper saving of $1272, makes a total of 14,300 + 1272, or $15,572, a sum well worth serious consideration.

Another important item is the cost of generating plant equipment, which will cost installed, approximately $125 per kilowatt. If compelled to handle this load at 80 per cent power factor, instead of at 90 per cent the additional expenditure for plant equipment would be 572×125, or $71,500.

This data has been worked out to show what the saving is by increasing the power factor, in this particular case, from 80 per cent to 90 per cent, but it is quite common to find systems with power factor ranging

as low as 65 per cent and the lower the power factor the greater will be the saving for the same amount of expenditure, and this method of attack should apply where it will be of the most benefit. This will assuredly be where the power factor of the system is below 80 per cent, and if put before the power consumer with proper explanations, he can certainly be made to see that it is to the mutual benefit of all concerned, and it will also, in many instances, be a big step towards the conservation of fuel, which is at the present time, and from all indications will continue to be more so, a big factor in the industrial welfare of our country.

Concrete Parts for Generators

USE OF IRON MAY BE ELIMINATED IN STATOR FRAMES AND THRUST BEARING SUPPORTS OF LARGE UNITS. BY C. M. HACKETT

THE MANUFACTURE of reinforced concrete may now be regarded as having reached the scientific stage. Haphazard methods will doubtless continue to be used in the selection of materials and in the manner of mixing for many kinds of work; but it is possible with our present knowledge of aggregates, cement, water and the methods of combining them, to get not only uniform strength in all parts of a concrete structure of large size and mass, but, also, to produce duplicates of that structure in any quantity desired. This progress, combined with the great strength of the finished product, has led to the adoption of concrete for various classes of work where metal has heretofore been regarded as the only suitable material.

There are two parts of large size, low speed, vertical shaft generators usually made of steel or iron that can with advantage be made of reinforced concrete, namely, the stator frame and thrust bearing support.

The use of concrete instead of metal for these parts does not involve any problems of stability or strength that cannot be readily solved by care in design and construction; and, provided technical and practical knowledge of conditions to be met are kept in mind when carrying out the work, the chances of trouble developing are no greater than with all-metal machines.

The concrete stator frame will, in most cases, be combined with the power plant structure.

If a house is to be built over the generators, the stator will likely be nearly, if not completely, below the floor level; but if the machines are to be of the out-of-door type, then it will generally consist of a cylinder between the operating floor and upper deck or platform, extending somewhat above the latter, and will be an important part of the support for that deck as well as a means of carrying the load imposed by the thrust bearing.

The main points to be considered in the design of the stator frame are ample cross section for carrying load, and reinforcement so placed as to distribute the stresses produced by short circuits and unbalancing.

Admission of air to the machine, as well as its discharge after having passed through the windings, will also form a feature of the design, and in case generators are of the out-of-doors type, and recirculation of air is necessary during a portion of the year, outlet ports and dampers for air control will be required in the stator as well as in thrust bearing supporting structure, so that the discharge of air from the machine can be regulated according to temperature conditions.

Securing of the stator laminations and windings to the concrete can be accomplished either by anchor bolts, spaced and arranged to support and adjust the clamps which hold the laminations, or by the use of a skeleton ring, cast in sections and machined to the proper form and dimensions. If a ring is used, it will rest on a shoulder formed in the concrete and will be bolted and grouted in place after the final adjustment of the rotor has been made. When the bolt type of support is adopted, the placing of the stator laminations and windings must be done at the power plant. They may be put in either at the factory or at the plant if the skeleton ring is used.

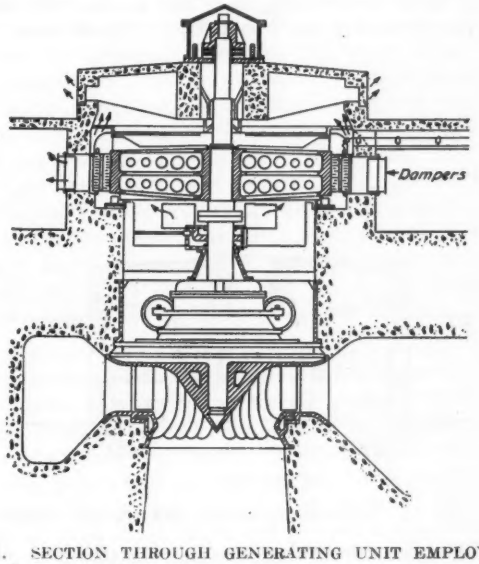


FIG. 1. SECTION THROUGH GENERATING UNIT EMPLOYING CONCRETE

The taking off of leads, the shrouding to control the direction of air, and the placing of vanes for driving it will be approximately along the same general lines as for an "all metal" machine. Also, the arrangements for braking and lifting the rotor will contain no novel features.

The bracket or bridge for supporting the thrust bearing may consist of a heavy floor or cover with deep girders rising from it, or the girders may extend below the floor in truss form.

In designing this part, the following points should be carefully considered:

The reinforcing steel should be of a high grade, viz., equal to the best structural steel.

In placing the steel, the heavy, or primary, bars should be located so that they carry the load to the best advantage while the lighter or secondary reinforcing should be so placed that there is no portion of the concrete that is not effective, not only for supporting the load, but for distributing and absorbing vibration. To

meet this latter condition, a massive structure is desirable.

To facilitate handling, eye bolts, or tapped sockets into which eye bolts can be turned, should be so placed that they are well tied into the primary reinforcing, and cause the structure to be held level when being lifted.

The bearing plates may be formed of steel plate if no adjusting of the position of bridge is to be made by them; but in case such adjustment is desired, then flanged castings, strongly anchored to the stator and bridge, with the necessary adjusting screws and allowance for the desired movement, will be required.

The simplest method of adjusting thrust and guide bearing housings will be by wedging and shimming, and to seam them in place after rotor is accurately centered. They should be so designed as to permit the pouring of grout into all open spaces between castings and concrete structure before anchor bolts are tightened. If desired, the guide bearing housing can easily be designed to allow for a small adjustment of that portion which holds the bearing shell and in this way make it possible to correct any inequality in the air gap.

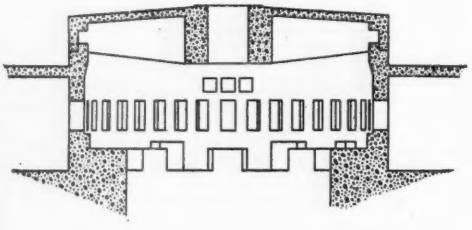


FIG. 2. SECTION THROUGH STATOR AND BRIDGE

The bolts for holding the bearing plates in position may be moulded directly into the concrete, but if anchor bolts are to be used for holding the bridge to the stator, properly located tubes of sufficient size to allow the bolts some play should be molded into the structure. It should be possible to remove anchor bolts from both the bridge and stator when the bridge is to be lifted.

Only the vertical type of machine has been considered in the foregoing; but it is also practical to build stator frames of concrete for large size horizontal shaft machines, using either a solid or split ring as may be desired. The housing or weather protection of such machines, if of the out-of-door type, can also be conveniently made of concrete, and provisions can be made for handling the sections of the housing if at any time it is necessary to do anything in the way of repairs on the windings.

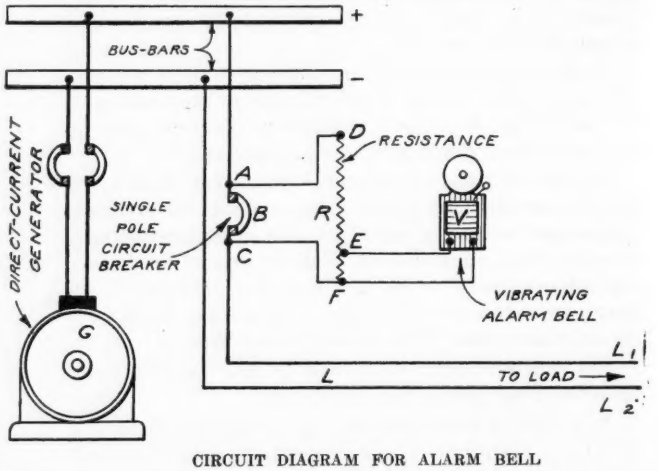
The economies to be found in the substitution of concrete for metal for parts of generators lie chiefly in the lower cost of materials and labor, reduction in shop expenses, and the saving in freight and handling charges. To these may be added a considerable saving in the cost of weather protection, if the generators are to be of the out-of-door type, since the concrete bridge structure can be water-proofed at a small cost, and its general design makes the effective protection of all joints and openings a simple matter.

A study of the advantages of the use of concrete in the construction of generators indicates that its special field lies with machines of large size. Just how far down the scale of sizes it is likely to show a gain over metal, can be determined only by time and experience. The indications are, however, that it will prove practical and economical in a fairly large field.—General Electric Review.

A Simple Circuit Breaker Alarm

By L. C. Harding

IN a certain plant, electrical power was transmitted over a line, L, which was of considerable length. Delay often ensued in closing the power station circuit-breaker B, after an overload had occurred at the far end of the line, due to the fact that the duties of the engineer were such that he could not remain permanently in the power house to watch the circuit-breaker. Consequently, an automatic alarm to notify the engineer of the opening of the breaker, was improvised as shown. Circuit-breaker, B, which protected the line, was of the single-pole type. A resistor, DF, of high resistance, was arranged in parallel around the circuit-breaker from the points A and C. Then an ordinary vibrating bell was connected across a portion of this resistor, as shown at EF.



CIRCUIT DIAGRAM FOR ALARM BELL

When the circuit-breaker is closed, practically no current flows through DF or through the electric bell, V, because path, AC, through the circuit-breaker offers much the least resistance; however, if the circuit-breaker is thrown open, current will flow through DF and through bell, V, provided line, L_1L_2, is closed at the load end by a machine being connected across it, or by some other conductor. With circuit-breaker, B, open, if the vibrating bell rings continuously, it indicates a short circuit at the end of the line L. The bell will continue to sound until the circuit-breaker is closed. This audible signal attracts the attention of the operator, who then closes the circuit-breaker.

Interchangeability of Squirrel-Cage Rotors

By B. B. Ramey

IN MILLS and factories where large numbers of induction motors are in service, emergencies often arise due to breakdowns, and repair parts are needed at once. While burnouts are not frequent on motors with squirrel-cage windings, they occur at times; also rotors and shafts are at times damaged in service, and when any of these troubles occur it is usually necessary to replace the complete rotating part. This is undoubtedly the quickest way of making the repair. It often happens that a spare rotor for the particular motor in trouble is not available. The following comments may serve to give some new ideas for such an emergency and help to get the motor back in service by using rotors for motors of other ratings that may be at hand. Thus the delay due to awaiting a new rotor from the manufacturer may be avoided.

The squirrel-cage rotor with its winding of bars and resistance rings fastened together by any of the well-known methods, has no groupings for poles, and when placed in a properly wound stator will respond to the synchronous speed for which the particular stator may be wound. The horsepower output is therefore determined by the stator that is used, since horsepower is proportional to the product of speed and torque. The squirrel-cage rotor does not set the speed nor the horsepower, but does control them to a certain extent; for the per cent slip is largely determined in the rotor and the starting torque and heating are affected somewhat, as outlined later.

It is to be understood, of course, that the rotor is correct mechanically to fit the stator; that is, the length of iron and air-gap should be correct. The air-gap could be off a few thousandths of an inch or the iron width could be slightly less or greater than the iron width of the stator without causing any trouble.

The other feature to consider is the electrical characteristics of the rotors. As stated above, the rotor will run at a synchronous speed as determined by the stator. In a line of motors of a given manufacturer, the rotor windings are usually such as to have a greater total actual resistance, the greater the number of poles; that is, a rotor for an eight-pole motor has a greater total resistance than a rotor for a six-pole motor and for a ten-pole motor greater than for an eight-pole motor, etc. The proportion of actual resistance in the resistance rings to that in the bars changes generally and is greater on the rotors for motors of larger numbers of poles. The effective resistance on a given rotor is, however, determined by the number of poles of the stator in which this rotor is being used and is usually greater for a small number of poles than for a large number of poles. Also the actual resistance and effective resistance in the bars are, in general, the same for rotors built for ratings of different numbers of poles, assuming the total bar section and length of bars to be the same. The difference is in the resistance rings; for instance, a six-pole motor will usually have copper rings of large section and a ten-pole motor will very likely have rings of copper of small section or rings of high resistance material, such as brass of proportionate section. The path of the current in the six-pole ring, however, is ten-sixths of that in the ten-pole rotor and for the same rings the effective resistance is greater as the square of this ratio. The greater effective resistance means more starting torque and higher percentage slip; that is, the full load speed is slightly lower, consequently there is a greater loss in the rotor; and vice versa for the lower effective resistance. By effective resistance is meant the resistance that is effective by virtue of the length of the path taken by the current in going through the bars or the resistance rings.

Assuming that the rotors are correct mechanically, the interchanging of the rotors will have in general about the following effect: If a ten-pole motor is having rotor trouble and a rotor from a six-pole motor is used in it, the per cent slip will be less, the starting torque lower, the efficiency slightly higher, and consequently there will be less heating. If a six-pole motor is having rotor trouble and a rotor from a ten-pole motor is used in it, the per cent slip will be greater, the starting torque higher, the efficiency slightly lower, and consequently there will be increased heating. Efficiency is not of prime importance, however, in case of emergencies, such as are being considered, but starting torque and heating are important. Similar interchanges of rotors could be carried out, such as four and eight poles, eight and ten poles, eight and twelve poles, ten and twelve poles, etc., remembering that the greater the difference in the number of poles, the greater the effect on the items of performance noted above. It is well, therefore, not to substitute rotors, when the difference in number of poles is too great, such as two and ten, or four and ten.

In making the interchange of rotors, if a rotor of a different number of slots from the standard rotor for the motor is used, it is best to use a rotor with a number of slots that is at least 15 per cent greater or less than the number of slots in the stator; otherwise, trouble due to low torque points may be experienced. The number of rotor slots will also have some effect on noise, but the question of noise is not important in most mills and factories, and a noisy motor could be tolerated in an emergency.

Aside from the question of quick repair in cases of breakdowns there are also other cases in which the foregoing comments may help to save time; that is, in cases where motors with high per cent slip are required, such as in punch, shear and other flywheel applications. For example, a six-pole motor may be available for a punch press, but has a rotor that gives a low per cent slip. A spare rotor for a ten-pole motor that is correct mechanically may be available, or there may even be a ten-pole motor in service, the rotor of which could be interchanged with the six-pole motor. The ten-pole rotor would perhaps give the desired per cent slip when used in the six-pole stator and the six-pole rotor would perhaps give sufficient torque when used in the ten-pole stator in the service that it is on. All of this would necessarily have to be determined by trial. Since higher per cent slip is desired in such a case as this, only rotors from motors with larger numbers of poles can be used, as going the other way gives a lower per cent slip.—The Electric Journal.

Oil Pipe Lines*

ADVANTAGES OF THE OIL ENGINE AS A MEANS OF TRANSPORTING OIL. SIMPLE FORMULAS FOR CALCULATION OF THE PRESSURE, NET HORSEPOWER AND BRAKE HORSEPOWER FOR TRANSMISSION OF OIL. BY S. A. SULENTIC

THE object of this paper is *(a)* to show the advantages of the oil engine as a means of transporting oil for long distances through pipe lines, *(b)* to compare the cost of pipe-line transportation with that of rail and canal transportation, and *(c)* to derive simple formulas that will make it comparatively easy for anybody to make quick calculations of the pressure, net horsepower and brake horsepower necessary for the transmission of any quantity of oil per day through a pipe of known diameter.

The cheapest method of overland transportation of oil is by pipe line. The cost in comparison to rail transportation is low, and yet when the rail cost is based on every-day practices, the amount seems very small.

In order to make a very crude estimate of the cost of transporting oil by pipe line when using equipment of the highest economy, assume a single line operating under the following conditions at a load factor of 80 per cent for 300 days per year:

Size of line	8 in.
Length of line	33 mi.
Pressure in line	700 lb. per sq. in.
Rate of discharge	900 bbl. per hr.

At this rate the discharge would be 21,600 bbl. per day or 6,480,000 bbl. per year of 300 days. Assuming 6.5 bbl. per ton, the yearly discharge would approximate 1,000,000 tons. The work equivalent of this discharge would be 33,000,000 ton-miles, calling for the continuous expenditure of 257 hp. as shown later. Assuming the mechanical efficiency of the engine to be 75 per cent, the actual horsepower necessary to install would be 257/0.75 or 342.

The assumed costs would be as follows:

Line: 33 miles at $1.65 per ft.	$287,500
Right of way at $0.25 per rod	2,640
Freight: 79 cars at $250	19,750
Haulage: 900 tons at $14.50	13,050
Laying pipe at $0.075 per ft.	13,060
Burying pipe at $0.20 per ft.	34,850
Engines, pumps, installed accessories	68,500
Pump stations, buildings and foundations	30,000
Tanks—	
Two 55,000-bbl. at $18,500 each	37,000
Two 500-bbl. at $500 each	1,000
Telegraph line: 33 miles at $550	18,150
Superintendence	2,500
Incidentals	6,000
Total assumed costs	$534,000

The operating expense, including fixed charges based on the total assumed costs, would be as follows:

Interest at 6 per cent	$32,040
Depreciation at 5 per cent	26,700
Administration	10,000
Attendance at pump stations and lines	11,500
Repairs to equipment, lines, etc.	4,000
Fuel for pumping—3000 bbl. at $2.65	7,950
Total operating expense	$92,190

*Presented at the annual meeting of the American Society of Mechanical Engineers.

Hence the cost of operation per ton-mile under the assumed conditions would be:

$$\frac{92{,}190}{33{,}000{,}000} = \$0.0028$$

or 2.8 mills per ton-mile. The relation between the cost of pipe-line transportation and rail transportation is in the ratio of 1 to 10.

It should be noted, however, that almost all of the pipe-line costs are fixed and are mainly independent of the amount of oil pumped. As a result, the transportation cost per ton-mile will vary almost inversely with the load factor of the line. If this hypothetical pipe line should be operated only 1/10 of the time assumed, the unit transportation cost would equal the rail cost. Furthermore, these figures are based on a life of 20 yr. (5 per cent amortization). A railroad would probably be used for various classes of freight as long as it existed, but a pipe line is of service only as long as oil is presented for transportation. If the pipe line in question were to become obsolete in 10 yr. through the exhaustion of the oil fields or other causes, the ton-mile cost would be greatly increased.

These figures have not been presented as those of an average case but only offered as "food for thought." In further consideration of the subject, however, it will not be out of place to give a few figures and examples showing the relations existing between pressure, capacity, diameter, length of line and power required.

Disregarding viscosity, the general hydraulic formula for friction head in a pipe discharging a uniform volume is

$$F = k\frac{v^2 L}{2gD} \qquad [1]$$

in which

F = friction head in feet of water = lb. per sq. in. ÷ 0.433
k = friction coefficient for 38 gravity oil = 0.024
v = velocity of flow, ft. per sec.
g = acceleration of gravity = 32.2 ft. per sec.
L = length of line, ft.
D = diameter of line, ft.

The formula for pressure in the line may be stated as

$$P = 0.433\,k\frac{v^2 L}{2gD} \qquad [2]$$

in which P = pressure in line in lb. per sq. in.

The discharge Q of the line, cu. ft. per sec. can be easily derived and stated as

$$Q = \frac{3.1416\,D^2 v}{4} \qquad [3]$$

in which Q varies directly as v. Since P varies directly as v^2 in Formula [2] and Q varies directly as v in Formula [3], it follows that P varies directly as Q^2.

The net horsepower required for a pipe line may be most readily calculated if we note that the pressure per square foot is equal to the number of foot-pounds required to displace 1 cu. ft. of oil, or

$$\text{Hp.} = \frac{144\,PQ}{550} \quad \ldots\ldots\ldots\ldots\ldots [4]$$

To sum up:

Velocity varies directly as the line discharge

Pressure varies directly as the square of the line discharge

Horsepower varies directly as the cube of the line discharge.

Another relation of value in making rapid pipe-line calculations is the ratio between the diameter D and length L with the discharge Q and the pressure P remaining constant.

From the friction formula [2] it will be seen that P varies directly as v^2L/D. Assuming P constant, L varies directly as D/v^2. For the same discharge, Formula [3], that is, with Q constant, v varies directly as $1/D^2$. Therefore v^2 would vary directly as $1/D^4$. Substituting this value for v^2 above, it is seen that L varies directly as $D/(1/D^4)$, or in other words, L varies directly as D^5.

This means that for the same discharge and pressure, i.e., the same friction, the length of the line would vary directly as the fifth power of the diameter. Taking a diameter of 6 in. as unity, the fifth powers of several different diameters are as follows:

D =	6	8	10	12
D^5 =	1.0	4.2	12.8	32

No doubt many other useful relations could be derived for the purpose of expediting pipe-line calculations, but those which have been presented are among the most useful.

In illustration of the foregoing, the following data in regard to the 36-mile, 8-in. Alton pipe line operating between Carlton and Wood River, Mo., should prove of interest. This line, constructed in 1913, has four stations, in each of which are installed four units each consisting of a 100-hp. type F. H. De La Vergne oil engine direct-connected to a 6-in. by 18-in. National Transit Co. herringbone-geared power pump with 8-in. suction and 6-in. discharge. The performance of one station equipment (three units) is given below.

Oil pumped during 10 days, bbl.....	140,000
Oil pumped per day, average, bbl....	14,000
Pressure maintained in line, lb. per sq. in.....	700
Brake horsepower, average.....	196
Pump efficiency, estimated, per cent.	85
Fuel consumed by engines during 10 days, bbl.....	65.8
Fuel consumed by engines per day, lb.	2,020
Brake-horsepower-hours per day = 196 × 24.....	4,704
Fuel consumption per b. hp.-hr., lb..	0.43
Ft.-lb. of work per day developed by the engines = 196 × 33,000 × 24 × 60.....	9,320,000,000
Ft.-lb. of work per day in oil pumped = 9,320,000,000 × 0.85 (85 per cent efficiency).....	7,900,000,000
B.t.u. in fuel consumed per day = 2,020 × 18,000.....	36,000,000
Ft.-lb. of work per 1,000,000 B.t.u...	217,000,000

Daily operating cost:

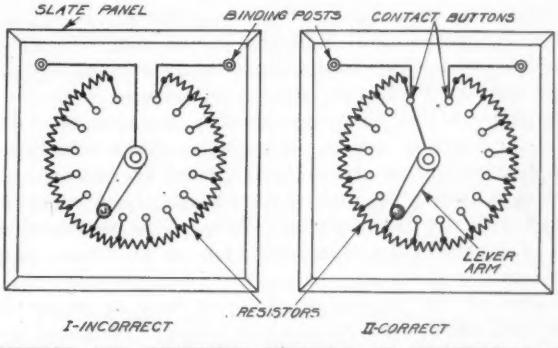
Fuel oil: 6.58 bbl. at $1.50.....	$ 9.87
Lubricating oil: 2 gal. at $0.22...	.44
Cylinder oil: 1.6 gal. at $0.21....	.34
Attendance: Total salaries of 2 engineers, 2 assistant engineers, 1 chief engineer and 2 telegraph operators	41.50
	$52.15
Cost per b. hp.-hr. ($52.15 ÷ 4704)..	0.011
Cost per bbl. of oil pumped ($52.15 ÷ 14,000).....	0.0037
Bbl. of oil pumped per bbl. of fuel consumed (14,000 ÷ 6.58).....	2,130

In conclusion it may be said that the comparatively small amount of power involved in pipe-line transportation lends itself admirably to the efficient use of the oil engine as a prime mover. And unless some other form of power can show better results in the immediate future, the oil engine bids fair to hold its present superiority as a means for the transportation of oil.

Proper Connections for Shunt-Field Rheostat

By M. M. Beach

DIFFICULTY may be experienced, due to the fact that the lever arm on a shunt-field motor rheostat does not always effect good connection with the contact buttons; this may result in the opening of the shunt field circuit. Then the motor will operate at abnormally high speed. In some instances, such trouble can



CORRECT AND INCORRECT METHODS OF CONNECTING UP SHUNT FIELD RHEOSTAT

be corrected by making a change in the connections. The general principle involved is illustrated herewith. If the connections are made as shown at II, the field circuit can never be open in the rheostat, even if the lever arm makes poor contact with one of the buttons. At I the incorrect method of connection, whereby the field circuit is open if the button contact is poor, is diagrammatically indicated.

In this country, long apprenticeships to the trades are not essential. It's ability that counts; and American wages are double the English wages and three times the French wages.

Monel Metal

Its Properties and Uses

USE OF monel metal in engineering work is being constantly extended. One large field of application is in the power plant, where its strength, together with its ability to retain a great portion of this strength at high temperatures, and the fact that it is practically non-corrodible, make it of considerable value. Monel metal is a natural alloy containing 67 to 68 per cent nickel, 28 to 30 per cent copper and 2 to 5 per cent of other metals, principally iron. By "natural alloy" is meant that the proportions of its various elements are practically the same as those of the ore as it comes from the mine. The only known deposit of monel metal ore is located near Sudbury, Ontario, Canada, which contains a supply estimated to be sufficient to last 100 yr. with a production of 2,000,000 lb. of metal per month.

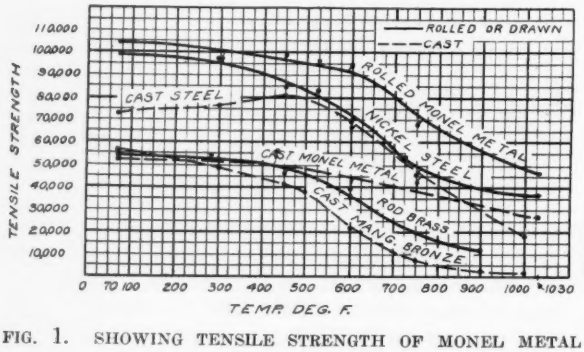


FIG. 1. SHOWING TENSILE STRENGTH OF MONEL METAL AND SEVERAL OTHERS

Although this deposit of ore was first discovered in 1884, it was not until 1905 that monel metal, as such, was produced; prior to that time, the nickel and copper were separated. In the latter year, however, a process was perfected for producing the alloy, monel metal. At first, it was only considered as an excellent substitute for German silver, which it surpassed in appearance, having a luster like that of pure nickel, from which it can hardly be distinguished. This led to considerable use for ornamental purposes, such as hardware, and the like.

One of the earliest engineering uses to which it was put, was in the form of a cast propeller on one of the ships of the U. S. Navy. Here it showed remarkable freedom from corrosion, as well as erosion. When examined after considerable service, its surface was found to be just as smooth as when installed.

Monel metal has a melting point of 1360 deg. C. (2480 F.). The tensile strength of rolled metal exceeds that of steel, as will be seen in Fig. 1, which is based on tables in Marks' Mechanical Engineers' Handbook. In the cast form, it is exceeded by that of cast steel and cast manganese bronze at ordinary temperatures, but at high temperatures monel metal leads in strength. Figure 2 shows the superiority of monel metal, at high temperature, as regards elastic limit. Its coefficient of expansion is very close to that of steel, being 0.000,013,75 per deg. C.

Taking the electrical conductivity of copper as 100 per cent, that of monel metal is 4 per cent. To determine its resistance to corrosion, tests have been conducted, one of which was immersion of pieces of monel metal in 40 deg. Baumé sulphuric acid for 56 days, at the end of which time the samples were found to have lost no weight. When borings, turnings, etc., were boiled in the same solution for 48 hr., the loss in weight was found to be less than one-half of one per cent.

The results obtained with the first monel metal propeller installed by the navy resulted in a number of other ships being fitted with propellers of this metal. The resistance of monel metal to the effects of heat, together with the similarity of the rates of expansion of monel metal and steel, has led to the use of monel metal for valve stems, discs and seats in cast steel valves for superheated steam work, where temperatures may range up to 700 or 800 deg. F. It is also used for turbine blading to a great extent, both on account of its heat resisting properties and its resistance to the erosion of the steam.

Other uses for monel metal are, condenser tubes, condenser nuts, pump valves, valve rods, piston rods and pump liners, especially where salt water or other corrosive substances are to be handled. When used in pump liners, it shows little wear and has been found to be free from scratches, and to have acquired a glass-like surface after considerable service. On account of its high resistance and comparative cheapness, it finds a good field in low temperature resistance work. Its resistance comes about midway between that of 18 and 30 per cent German silver wire.

As a roofing material, it is unexcelled, particularly in places where subject to corrosive fumes in the atmos-

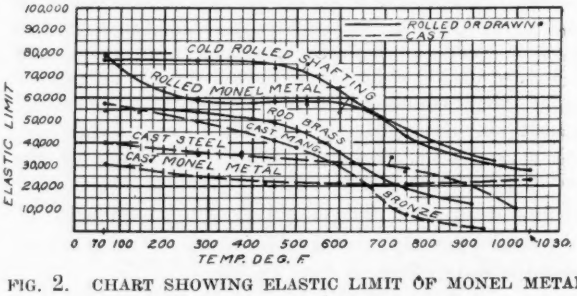


FIG. 2. CHART SHOWING ELASTIC LIMIT OF MONEL METAL AS COMPARED TO SEVERAL OTHERS

phere, as in smelteries, or acid plants. It is recorded that several years ago, one of the smaller German railroads, which on account of the poor coal available, had had to line its locomotive fireboxes with copper, tried out monel metal in one of its fireboxes, and that the results obtained were such as to cause a number of other locomotives to be so equipped. Another field for its use is in refrigerating plants where its non-corrodibility is of special value. Monel metal can be submitted to the same manufacturing processes as iron or steel, as well as the common non-ferrous metals. It can be cast, rolled, drawn, welded by either the electrical or oxy-acetylene process, soldered or brazed. It can be drawn as fine as No. 40 wire, and in spite of its apparent hardness it is comparatively easily machined.

"Most men who find themselves 'slipping' put the blame on others."

Combustion Control

SOME METHODS EMPLOYED; NEEDS FOR STOKERS OUTLINED. BY JOHN VAN BRUNT

THE ECONOMICAL use of coal in the boiler room is a matter that interests everybody who owns or operates a boiler plant, and with the prevailing high cost of both coal and labor, any reasonable expenditure will pay a handsome dividend, always provided the expenditure is intelligently directed.

As a means of improving economy the mechanical stoker is already recognized, and is in such general use that the question I am discussing may be considered only as applying to stoker fired plants.

There are two ways in which continued efficient operation may be maintained: first, by the employment of skilled technical or trained operators, who are guided by the requisite instruments, and second, by the use of a correctly designed and applied automatic regulator, which will vary the flow of air to the stoker or the draft at the damper, and the amount of coal fed to the furnace, in accordance with the output of steam.

OPERATION OF REGULATORS

THIS SORT of regulation has seemed to be simple and easy of accomplishment. There are fan engine regulators and damper regulators galore. Many stoker manufacturers furnish such regulators with their stokers, and by continued advertising have created a demand for such regulation, so that now the average customer demands some form of automatic regulation with his stokers. In the meantime, the stoker manufacturer has found that the regulators he has been furnishing do not regulate, or in so regulating, introduce other conditions that are worse than those that were to be avoided by their use.

The average regulator in use today, although supposed to be compensating, in most cases does not function so that the air pressure is proportional to the load, but functions so that the air pressure varies inversely to the steam pressure; and, further, it usually so operates that with a slight drop in steam pressure the throttle opens wide, and conversely closes with a slight rise in pressure. As a result, the fan runs at either the maximum or the minimum speed, neither of which corresponds to the load carried; or in the case of a natural draft stoker, the damper is either wide open or tight shut. Hence, if the average load on the boiler is 150 per cent of rating, the regulator operates to develop 200 per cent of rating for a few minutes, followed by 100 per cent of rating for a similar time, or perhaps 250 per cent part of the time and 50 per cent the rest. It is needless to point out that good efficiency is not obtainable under such conditions.

There are some combustion systems in which an attempt is made to regulate everything pertaining to combustion—draft over and under the fire, feed of coal, thickness of fuel bed, etc.—nearly everything but the fireman's morals. The writer is one who believes that there are too many variables to be controlled accurately, and that such system requires too constant skilled attention and frequent readjustment to be practical for the average boiler plant.

WHAT IS NEEDED

A REASONABLE degree of regulation of the air supply or boiler damper, either with or without fuel regulation, should prove of great advantage in most cases, assuming, of course, that the regulator regulates as it should, and not as most of them do. With a fairly steady load, the coal feed need not be varied for long periods, and when necessary may be adjusted by hand.

What is needed is a regulator which will function something like this: Assume a boiler plant of several boilers with forced draft stokers in which the load varies from 100 to 250 per cent of rating. Assume that the air pressure required to develop 100 per cent of rating is 1 in., 150 per cent of rating 1½ in., 200 per cent of rating 2 in., or that the air pressure is directly proportional to the output of the boilers.

A regulator which will be sensitive, accurate and positive enough to pass just sufficient steam to the fan turbine, to give the air pressure required for the corresponding rating, is the one that will fill the bill. The changes in fan speed will be gradual, avoiding excessive wear and tear on the fan and turbine engine. At no time will there be more air than required for the load existing at that time, nor will there be less. The curves of rates of steam flow, coal feed and air pressure will parallel each other.

Industrial Power Plant Costs

BY B. W. DENNIS

CENTRAL station engineers, when estimating the cost of power to substitute in the place of a privately owned plant, frequently omit the addition of items covering the cost of a plant which would furnish steam, compressed air, water, gas, refrigeration and heat to the factory which the power plant is serving. In case air, water and refrigeration are to have electrical driven machines, the additional cost of these is a necessary item; and the loss of exhaust steam—for heating—from these steam driven units is quite a loss indeed.

For the many processes of heating, drying, etc., which require steam, a small steam plant is absolutely necessary in most cases, and is also required for oil and gas systems. The operation of this smaller steam plant, in addition to the electrical equipment made necessary by the changing to central station electric power, will sometimes be found to equal the cost of operating the complete steam station necessary for the entire electric and steam loads. Each factory has its own problem; but in this climate (Northern U. S.), the steam load, on a factory of much size having a well operated plant, will cause the balance in cost to fall in favor of the privately owned industrial power plant, and this has had the added advantage of continuity as shown by the plants operating during the late coal shortage.

"WHEN you're done pumping, leave the handle."

Experiences at the Glendale Plant

BLAKE MEETS GOOCH AND WRITES HIS FRIEND WALLACE, AT BRIDGETOWN, FOR FURTHER INFORMATION. BY G. H. KIMBALL

DEAR WALLACE: Things are no better here than when I wrote last. Jones can do nothing in the way of building up the plant, and I expect to see him go very soon. I heard last week that the manager is looking for a good Diesel engine man, and will pay any price in reason. That's the way they all talk after a capable man has gone, because he could not get a few dollars more. It is the old story all right.

Speaking of the oil engines; last year when you were in charge, there was a regular routine of grinding valves, adjustments and inspection of all parts. More work was done in two weeks than in all of the time since you left.

The day before yesterday, Wilbur came into the plant with a man whom he introduced as Mr. Gooch, and he said he was applying for the job. I had a talk with him and found that he is from your place. You have told me something about him already, but he wishes to run only the oil engines, and not the steam engines and other machinery. Wilbur wishes me to have charge of

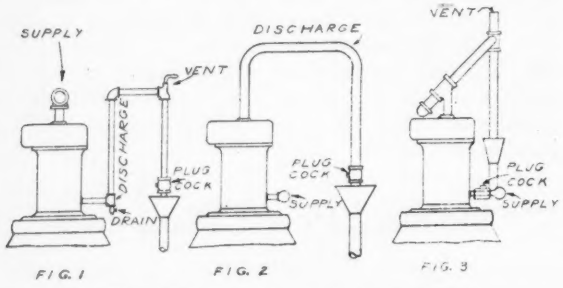


FIG. 1. ORIGINAL COOLING WATER PIPING
FIG. 2. CORRECT PIPING ARRANGEMENT
FIG. 3. MR. CURLY SUGGESTS THIS ARRANGEMENT

the rest; now, if Gooch is the right man to work with, I would take it; otherwise, I don't want it that way. If you will tell me all you can about him, I will decide about it.

Your friend,
JOHN BLAKE.

WALLACE GIVES HIS OPINION OF GOOCH, AND REPORTS DOINGS AT BRIDGETOWN

DEAR JOHN: Strange things happen sometimes outside of stories. In some earlier letters, I have told you of how Gooch acted when I came, and how much he thinks of his own ability. He has spent a large part of his time advertising himself as an oil engineer, and being very skeptical about other people's good points. Such a man does not fit with most people, and I always felt that there is something wrong with any person who makes light of every difficulty before he understands it.

From what I have learned, the service from the oil engines here has not been satisfactory, and I know that it is largely due to his lax methods of operation and repair. He has done everything possible to discredit my work with Mr. Curly, the superintendent of the Power Department, and even with the officials of the company. He has done nothing since I came here that has met with the approval of Mr. Curly, and now he has probably been recommended by the former superintendent and comes to Wilbur for a job. If the arrangement is made as you have described, it cannot fail to lead to friction, and all of the evils that divided authority causes. How can such a man make good? So now, use your own judgment.

The foundation for the other unit having been made, the riggers under the direction of Mr. Muggs are slowly pulling it over the ground in pieces toward the new location. It is a considerable weight, for each three-cylinder part weighs 50 tons, so that two bridges have had to be strengthened in its course. We shall be very busy getting it in shape to run.

Some little questions of operation have already arisen. The superintendent knows nothing about oil engines, but he has had some experience with large gas engines and when this unit was piped, the water to the cylinders was connected as shown in Fig. 1. In this arrangement, it is plain that the coldest water strikes the hottest parts first. All practice in gas and oil engines indicates the exact reversal of this method as in Fig. 2. With Diesel engines, it has been recommended by the company to run three (3) separate pipes to the funnel so the water from each cylinder can be tested and controlled with ease. Mr. Curly wishes to install the arrangement in Fig. 3, which will require closer attention, but will probably work all right. Just now, we are using water direct from the town supply, which is expensive, for it is probable that the water costs as much or more than the fuel; but we are installing a motor driven triplex pump similar to yours that will draw from the river.

The exhaust from this engine is piped into the woods, so that the black smoke will not soil the factory that is 200 ft. distant, but there has been no smoke yet and I conclude that they got the idea from the first unit that is now being moved.

Yours truly,
WILLIAM WALLACE.

U. S. CIVIL SERVICE COMMISSION announces examinations as follows:

Mechanical Draftsmen, to fill vacancies under the Navy Department for duty at naval establishments in the Fourth U. S. Civil Service District; salaries ranging from $5.20 to $12 a day.

Specification Engineer, March 2, to fill a vacancy in the office of the Chief Signal Officer, War Department, Washington, D. C., at $2000 a year, and vacancies in positions requiring similar qualifications.

Mechanician and Laboratory Assistant, March 3-4, to fill a vacancy in the Bureau of Mines, for duty at Berkeley, Calif., at $5.25 a day, and vacancies in positions requiring similar qualifications.

Apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

Dangers from Coal Dust

BUREAU OF MINES MAKES INVESTIGATION INTO EXPLOSION HAZARD IN STEEL MILLS ARISING FROM PARTIALLY CONSUMED COAL DUST. BY L. D. TRACY

FOR many years, natural gas has been the principal fuel used in the heating furnaces in those mills located in the Pittsburgh district which manufacture bolts, nuts, rivets, picks, mattocks and small forgings. For a number of years, the steady supply of this fuel has been more or less interrupted, owing to the increased demand for domestic use and to the increasing difficulty in securing an adequate amount of natural gas.

This condition has led a number of the steel companies to substitute pulverized coal as a fuel for the furnaces. Elaborate installations have been made for pulverizing the coal and conveying it to the furnaces. Soon after the furnaces commenced to operate with pulverized coal, large quantities of fine dust began to accumulate on the platforms over the furnaces, the roof trusses, on the outside of the various pipe lines, electric cables and even on the roofs of the buildings.

Some of the companies, becoming alarmed, requested the Bureau of Mines to make an investigation to ascertain the liability of this dust to cause an explosion. While conducting this investigation, an explosion occurred in another mill which caused the death of one man and severely burned two others.

Eleven samples of the dust (which for convenience has been termed "mill dust") from various locations in the different mill buildings were taken and submitted to chemical analysis, microscopic examination and also to flame and explosion tests.

From the chemical analyses, it was found that the volatile matter in the dusts ranged from 6.3 per cent to 23.54 per cent, fixed carbon from 50.88 per cent to 67.08 per cent and ash from 22.29 per cent to 32.16 per cent.

Five samples of the pure coal dust, before passing into the furnace, were subjected to a chemical analysis and it was found that the volatile matter in the coal ranged from 30.50 per cent to 36.81 per cent, the fixed carbon from 46.86 per cent to 52.48 per cent and the ash from 9.26 per cent to 21.84 per cent.

Under the microscope, a sample of mill dust, which by chemical analysis showed 23.5 per cent volatile matter, was found to contain a very large proportion of very fine partially coked coal dust, a small proportion of fine or medium fine partially coked coal dust and some dust thoroughly coked. In addition, a considerable portion of yellow resinous appearing matter, some particles of carbon which might be termed soot and some small particles of ash were found.

A sample, which by chemical analysis was found to contain but 11.25 per cent of volatile matter, under the microscope showed only a relatively small proportion of medium sized partially coked coal dust and many thoroughly coked particles.

From these examinations and analyses, it would seem that, for some reason, the pulverized coal was being blown out of the combustion chambers of the furnaces before it had been thoroughly consumed.

The several samples of dust were also subjected to tests to determine the pressure which might be exerted by the dust in a possible explosion, as compared with pure pulverized coal. Briefly, this test apparatus consists of a glass globe, possibly six inches in diameter, containing a small platinum coil which is electrically heated. A sample of dust is blown against the heated coil and the pressure of the resulting explosion is recorded by a pressure indicator. In these tests about 0.003 oz. of pure pulverized coal was blown by about 8 cu. in. of oxygen under a pressure of 5½ in. of mercury against the platinum coil, which had been heated to a temperature of 2200 deg. Fahrenheit. The average pressure obtained was 14.5 lb. per square inch.

A sample of the dust, containing 23.54 per cent volatile matter, exploded in the apparatus with a recorded pressure of 10.21 lb. per sq. in., a second sample containing 20.6 per cent volatile matter recorded a pressure of 8.7 lb. per sq. in., and a third sample with 15.91 per cent volatile matter recorded a pressure of 4.6 lb. per sq. in.

It will be noted that the sample containing 23.54 per cent of volatile matter registered a pressure but little under that of pure coal dust.

When the small quantity of dust which was exploded is taken into consideration and a pressure of over 10 lb. per sq. in. is obtained, it will readily be seen that, with a large amount of dust exploding, the pressure would run much higher, if confined.

Further experiments to determine the explosibility of the mill dust were carried on in the dust explosion gallery of the Bureau. This is essentially a horizontal wooden box, 6 in. deep by 6 in. wide and 14 ft. long, made of 2-in. planks, held together by wooden clamps and iron rods, in such a manner that the top may be removed. A metal flap valve covers the back end of the gallery, the other end being left open. At uniform distances along the entire length of the floor of the gallery are 14 holes, into which are fitted ¾-in. pipe jets projecting vertically from a 2-in. horizontal pipe extending beneath the floor of the gallery. The back end of this pipe is closed by a cannon having a capacity of about 1/5 oz. of powder, the other end being left open. A loose metal disk covers the end of each jet leading into each hole in the floor of the gallery, thus forming a pocket for the dust, about 1/10 oz., with which each hole was loaded.

Each hole is covered by a small square of coarse, heavy screen held in place by large washers bolted to the floor of the gallery. The purpose of this screen is to diffuse the dust into a cloud of more uniform density.

The gallery was loaded by pouring about ⅛ oz. of the "mill dust" in each of the 14 holes in the floor of the gallery. The squares of screen were then placed in position over each hole.

The cannon in the end of the horizontal pipe beneath the gallery was loaded with about 1/6 oz. of powder, and about ⅓ oz. of loose powder was placed between the first two holes in the floor of the gallery. After the loading of the gallery had been completed, the top was

bolted on and the electric firing wires were connected. The explosion of the powder in the cannon served to raise a dust cloud and the loose powder was used to start the initial explosion of the dust cloud.

Cannon and loose powder were fired by means of electric spitters, the cannon being fired two seconds before the loose powder.

From the described tests here and from similar tests with dust from the steel mills of other companies, it has been fairly well demonstrated that the division point between mill dust which will explode and that which will not explode, is reached when the dust contains about 11 per cent of volatile matter.

A good example of the great danger from mill dust, caused by the use of pulverized coal, is the first which occurred a few years ago in a plant in which there were a number of puddling furnaces, some of which used pulverized coal as a fuel. A draft of air blew some of the coal dust over some red hot iron or slag. The dust immediately ignited and communicated the flames to the roof trusses. These were covered with fine dust which caused the roof to burn so quickly that the men barely escaped in safety from the building.

Many of the systems distributing coal dust to the furnaces consist fundamentally of fans which drive the dust from the storage bins through large pipes, from which small feed lines lead to the burners. It is the practice in some mills, when the furnaces are shut down, to stop the fan before all the pulverized coal in the pipe line has been thoroughly blown out. This is a rather dangerous practice for the reason that, when the pressure from the fan is stopped, there is likely to be a back draft from the furnace which may take live sparks into the feed line. These sparks will smoulder until the fan is started again and then will be fanned into a flame, igniting the dust in the feed line with a consequent explosion. The fatal explosion mentioned in the first part of this article was evidently caused in this manner.

Roof trusses, pipes, platforms and all other places upon which any considerable amount of dust might accumulate should be kept thoroughly cleaned. While cleaning these trusses, platforms, and so on, no flame torches or open lights should be used because of the danger of igniting any dust cloud which might be raised.

All electric switches and motors should be kept from dust and all electric wiring should be kept away from any place where dust in large quantities is likely to accumulate. As far as possible the wiring should be carried in conduits.

Provision should be made to protect properly all pulverizing machinery from damage which might be caused by an explosion due to the ignition of coal dust from static electricity in the machinery. All conduits, grinders and other parts in which an electric spark might be produced should be grounded. Care should be taken that there is no way in which the coal dust can come in contact with hot metal, especially where pulverized coal storage bins are in close proximity to hot metal or hot slag.

In some of the furnaces in which natural gas has been used, it is customary to keep both the gas and pulverized coal connections ready for service. If coal is being used, the gas connection should be cut out as there is a chance that a leaky valve may allow gas to accumulate in the main coal feed and become ignited by a back fire from the furnace.

The substitution of powdered coal for natural gas in the heating furnaces of the steel mills is of comparatively recent date, and there is hardly any doubt but that the practice will become more general in its application as an adequate supply of natural gas becomes more difficult to obtain.

As the problem of mill dust and the consequent danger therefrom seems to be prevalent in some plants using pulverized coal, it would seem imperative that every mill official should take precautions to prevent loss of life and property by an explosion or fire from this dust.—U. S. Bureau of Mines, Reports of Investigations.

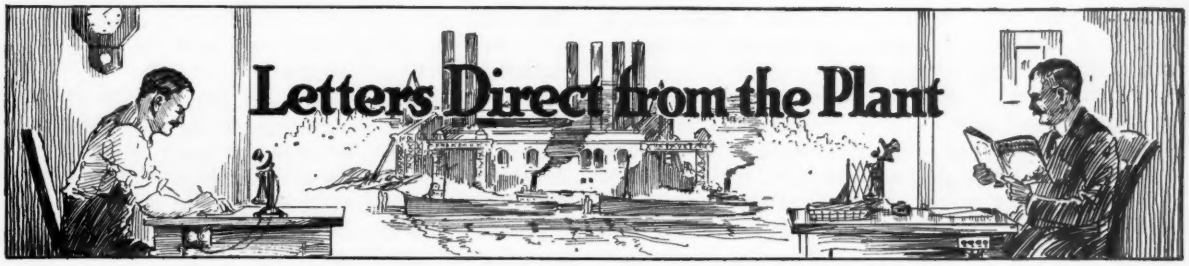
Imports and Exports of Crude Petroleum in 1919

THE table given below was compiled from the records of the Bureau of Foreign and Domestic Commerce. The figures, which are expressed in barrels of 42 gal. each, are subject to revision. The excess of imports over exports for the period Jan. 1 to Nov. 30, 1919, was 43,535,089 bbl. (preliminary figures), while for the same period in 1918 the total was 30,173,050 bbl.

TABLE SHOWING IMPORTS AND EXPORTS OF PETROLEUM

Month	Imports			Exports	Excess of Imports over Exports
	Mexico	Other Countries	Total		
Jan.	3,899,376	26	3,899,401	339,382	3,560,382
Feb.	3,656,542	84	3,656,626	183,503	3,472,123
Mar.	3,493,800	981	3,493,781	218,394	3,275,387
April	3,970,195	14,000	3,984,195	277,919	3,706,276
May	4,743,395	5,000	4,748,395	177,224	4,571,171
June	4,703,212	24,929	4,728,141	254,470	4,473,671
July	4,462,910	24,742	4,487,652	205,642	4,282,010
Aug.	4,143,445		4,143,445	185,694	3,957,751
Sept.	4,405,005		4,405,005	1,721,586	3,683,419
Oct.	5,886,290	159	5,886,449	1,123,448	4,763,001
Nov.	4,938,881	319	4,939,200	1,149,302	3,789,898
Dec.					

U. S. CIVIL SERVICE COMMISSION announces an examination for Piping Draftsman, to fill a vacancy in the Naval Ordnance Plant, South Charleston, W Va., and in positions requiring similar qualifications at other naval establishments in the Fourth Civil Service District. Competitors will be rated on physical ability, education, training and experience. Salaries range from $5.20 for Draftsman, Grade C, to $10-$12 a day for Chargeman. Applicants for Grade C must (a) have been graduated from a technical school or college of recognized standing, with 3 yr. experience in drafting in the line in which application is made; (b) have been graduated from such an institution with the completion of a course therein prescribed for the line in which application is made; or (c) have had 3 yr. experience in shop, field or office in the line in which application is made, 2 yr. of which must have been in the drafting room. Apply for Form 1312.



Mountain Engineering

IT HAS BEEN said that necessity is the mother of invention, and during the world war necessities were numerous and inventions various.

City engineers often jest of the country or backwoods engineers, as they sometimes call them, but the engineer in a power plant distant from a city is more often obliged to depend upon his ingenuity than the engineer in a city plant. The engineer of a city plant telephones for packing, pipe fittings and considerable of his light material, and in a short time, if not at once, it is delivered to him. He can also, upon short notice, have mechanics of various trades come in and perform much of his repair work for him, while the country engineer often has difficulty in securing the proper material, and then may be obliged to perform the principal part of the labor himself.

During the war, it was decided to erect a small sawmill, in a mountainous district, as quickly as possible.

The machinery and a return tubular boiler were shipped to the location. It was then learned that there would be difficulty in securing enough bricks to set up

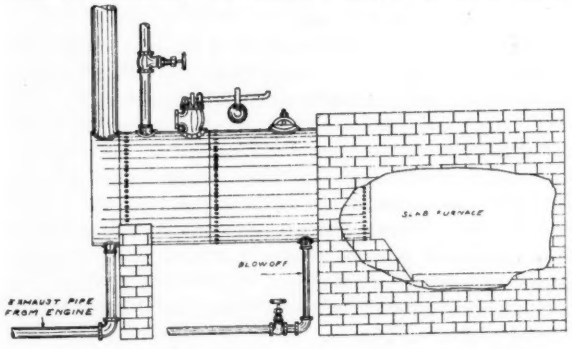


FIG. 1. EMERGENCY SETTING FOR RETURN TUBULAR BOILER

the boiler. Some bricks were received, but far from sufficient to set the boiler as it should be. The orders were to get busy and saw wood.

Here is where the country engineer used his head, with the result shown in Fig. 1. The boiler was raised and two brick supports built under it. At the rear end a furnace was built of stone and brick in such a manner as to permit burning slabs. The exhaust from the engine was piped into the bottom of the smoke box, and a "running draft" established.

The trick was turned and so was the saw, and they did their bit to help make the country safe for democracy, even if some of the arrangements were not just according to the A. S. M. E. code.

Calculations were not made as to efficiency or heating surface. There was no danger of overheating the shell plate with this setting. The boiler was second-hand, of butt strap construction, as shown in Fig. 2. There was a row of rivets through the center of the joint. I have been unable to determine why the row of rivets was added in the center. I would like to hear

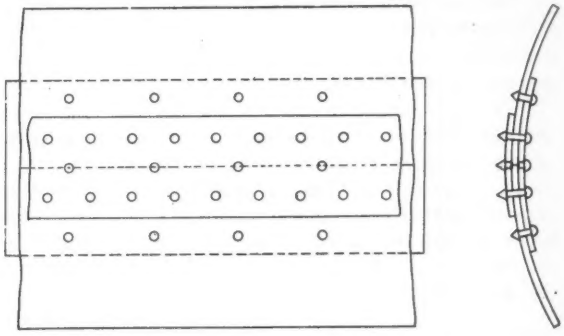


FIG. 2. AN UNUSUAL BOILER SEAM

if any of the engineer or boiler maker readers of Power Plant Engineering have seen a joint of this kind and can give the reason for this design. I. B. LEAVITT.

Observations on the Use of Fuel Oil

MUCH HAS BEEN WRITTEN on the advantages of oil over coal, and in the main these advantages have been admitted.

In 3 yr. experience with oil in a 10,000-hp. plant, we have made the following observations: The soot from oil is much harder to take off the heating surfaces of boilers and economizers than coal soot, and there is more deposited than is generally thought.

We are of the belief that in order to obtain satisfactory results, oil requires a larger chimney than the rules for chimney design of oil burning plants will show to be necessary.

A chimney that is clear, showing no smoke, whether oil or coal is burned, indicates that too much air is entering the furnaces and a serious fuel waste results.

We have analyzed the gases from 20 boilers when the 250-ft. chimney showed no smoke from the roof, 60 ft. from the ground, and such analysis showed an excess of air. The air supply to the several fires was reduced until a satisfactory CO_2 was obtained, when an observation of the chimney showed a light brown haze coming out. We had the correct supply of air and daily operation has since proved the correctness of this operation.

Following is an example of the simple, easy and flexible operation of a boiler plant under heavy load when using oil, as compared to coal.

In the plant referred to we run three 365-hp. boilers to carry the night load, the fires under the other boilers

being banked after cleaning. The load comes on at 6:45 a. m. and then throughout the day the boilers are run at 150 per cent rating.

When coal was used, to enable the firemen to get the fires up and into an active condition to carry the load, a demand had to be made on the boilers for steam and, of course, it would not do to let the safeties blow during the time the fires are getting into condition.

Therefore, the 6-in. live steam connection to the heating system as far as that is available and drawing on the boiler for the remainder, was opened and the back-pressure valve re-set to open at a low pressure so the steam would blow into the atmosphere.

This resulted in a direct waste of about 200 tons coal per year.

Using oil, the burners under the boilers floating on the line are reset 5 min. before starting time, and the steam pressure raised from 120 to 165 lb., as the only steam demand is that for warming the engines and to operate the auxiliaries.

We have found that when trouble has resulted in damaged boilers when burning oil, it has been caused by careless or ignorant handling by the men getting up steam too quickly so that the boiler suffered. While perhaps not actually necessary, we believe that no oil fired boiler should be forced to generate steam and be cut into the line in a shorter period of time than good practice and judgment demand when burning coal.

RECEIVER.

Faulty Engineering in Oil Refineries

THE TECHNIQUE of mechanical engineering does not seem to impress the average chemist as a matter of much moment. That chemistry is a highly technical pursuit, calling for a trained intellect and much skill, is acknowledged by engineers and freely admitted by most chemists. Engineering, however, is so closely allied to "drafting" that some people regard the two as identical functions—that to become an engineer, all that is necessary is to become skilled in drawing. In fact, I was recently informed by a chemist that he seriously contemplated taking up drafting in order to avoid the occasional employment of an engineer. A knowledge of chemistry and drafting apparently makes a "chemist-engineer."

There are several industries that have grown large and financially successful, due to the efforts of chemists, but which, on the other hand, evidence much that is mediocre in engineering and which cannot be called successful from the standpoint of economy. I place at the head of the list in this regard the oil refinery.

That the average refinery in the oil fields is wasteful of fuel, inefficient in operation, and has been built with the purpose of departing as little as possible from precedent, seems to be common knowledge. But one would think that the large refinery, sometimes hundreds of miles from the oil fields and representing an investment of millions, would show the latest in mechanical design and be operated with the highest possible economy.

This last was my impression when fortunate circumstances permitted me to make a detailed study of the so-called "cracking" plants in several refineries. These plants were in direct and responsible charge of chemists. I did not meet an engineer and so concluded that there weren't any or that they were not of sufficient importance to be in evidence.

I really wanted to meet an engineer because there were a number of purely engineering features which I wished to discuss. Attempts to learn anything from the chemists (who were constantly on their guard lest they disclose some great secret) almost left me with the impression that the things which I regarded as monstrosities were really the result of development—that a slight departure from just this, or that, would result in failure; and yet no two layouts were exactly alike. Were one gullible enough, one might be made to believe that fittings with left-hand threads were necessary to the success of the operation or that the left-hind-foot of a rabbit would exercise a potent charm.

A typical layout of pressure still is a shell 8 or 10 ft. in diameter and 30 ft. long, with convex or bumped heads. This is partly enclosed in a brick setting after the fashion of a cylindrical or return-tubular boiler. The vapor from the contents of the still passes to the radiators or "harps" through the vapor pipes. These pipes are 12 in. in diameter. Some stills are provided with one vapor pipe, but most of them have two, and many of the larger stills have three.

Just how the size and number of vapor pipes are determined I did not learn. From a consideration of vapor velocity, the capacity of these pipes is, in the light of steam plant practice, ridiculously large. And, if they are intended to be radiators, they are inefficient as well as uneconomical. I was informed that the pitch of these pipes was an important factor and exercised considerable influence on cracking results. The pitch varied from about 2½ to about 13 deg.

The vapor pipes discharge to a 12-in. header. This header is connected by two 12-in. nipples to another 12-in. header above, which serves the radiators, or harps. The harps are short lengths of 1½-in. pipes welded at both ends to 4-in. or 6-in. manifolds, their general appearance suggesting the name. From the upper manifolds of the harps are two 4-in. pipes (one at each end of the bank of harps), which connect with the condenser. The condenser is a vertical coil of 4-in., 3-in. and 2-in. pipes submerged in a tank of water. The product leaving the condenser is the "gasoline," which passes through the "tail-house."

The submerged condenser has, in other industries, been found the least efficient of any of the types, and why it is used so extensively in the refinery I do not know. This may, however, be due to the almost blind following of precedent.

Many of the 8-ft. stills have ⅜-in. shell plates, the heads being ½ in. thick. The longitudinal seams are lapped and triple riveted. The girth seams are double riveted. The pressure carried is 80 lb., which, considering the plate thickness, would be regarded high in steam practice. In addition to this is the weakening effect of the high temperature (above 700 deg. F.) and the deteriorating effect on the bottom plate, of the accumulation of coke. Boiler insurance companies would not regard these stills as good risks.

About the first thing to attract one who is versed in power plant practice is the proportion of heating surface to grate surface. The grate surface, regardless of

the size or type of still is 40 sq. ft. In many of the 8 by 30 ft. shell-stills the heating surface is 250 sq. ft. This ratio of heating to grate surface (6¼ to 1) does not exist in any other industry with which the writer is familiar. In one installation of this size of still, the ratio is 4¼ to 1. The highest ratio was found in the tube still installations, which are all equipped with chain-grate stokers, the ratio being 29 to 1 and 37 to 1.

I do not believe that there is any consideration of heat transfer, or practical operation, that requires such large grates. In addition to the coal on the grates, oil gas is burned at the rear of the setting.

On the subject of draft and furnace design, there is evident a woeful ignorance. In no case did I find a sufficient flue area, based on grate area, and obstructions to the flow of the gases were many and serious. In one installation, a baffle wall was brought to about 5 in. of the still shell, the area of the opening being a little more than 3 sq. ft. In some installations, the gases of combustion made, between grate and stack, the equivalent of six sharp right-angle turns. In nearly all these installations, the draft is augmented by small turbo-blowers located in the front of the setting.

The ideas represented in the several layouts were many and varied and gave the impression that a number of people were experimenting with the hope that a certain adjustment or "kink" would improve still performance. Much of this could be avoided if the experiences of men in other industries, but with similar plant, were heeded.

So far from other industries suggesting practical schemes, there appears to be a willful disregard of other industries. In fact, there appears to be an impression that because oil refining on a large scale is a comparatively new industry, the science of other industries does not apply. In other words, two and two make four in most industries; but in the refining game it is something else.

These refineries are provided with power plants of high grade, equipped with the usual fuel saving apparatus. It would seem that if the men who designed the power plant were intrusted with the design of the refining apparatus, we would not be treated to the spectacle of plant that is, in all essential features, similar to power plant apparatus, laid out as were power plants of 40 yr. ago.

Of interest to all concerned with fuel economy is the high temperature of the flue gases. I learned that this was seldom lower than 1100 deg. and was often as high as 1600 deg. Some such thing as this could be inferred from the grate, furnace and still proportions.

When one thinks of the preventable fuel waste in refineries, the wonder is that it did not attract the attention of the U. S. Fuel Administration. Small power plants were required to fill out questionnaires for the purpose of disclosing fuel waste, yet the large refineries were wasting fuel at a rate that would make power plants "pikers" by comparison.

I was told (by a chemist) that the fuel waste was unpreventable; but when stack temperatures range from 1100 to 1600 deg. and the temperature of the oil in the still is not over 750 deg., it would be hard to convince a power plant engineer of the accuracy of the statement.

In the literature of the refining industry, one is dismayed by the array of patent; and a study of the patents granted gives one the impression that many people have rushed to the patent office on very slight provocation.

Conditions described in the foregoing are only what can be expected when men, however well qualified in their own line of endeavor, invade a field with which they are unfamiliar. Until engineers are consulted on questions of engineering, these conditions will continue, pending, of course, the advent of the chemist who is also an engineer.

C. O. SANDSTROM.

A Swimming Tank Vacuum Cleaner

I ONCE had charge of a plant in connection with a 200,000-gal. porcelain lined, concrete swimming tank in a public bath house. The attendance occasionally was as high as 1500 bathers a day, with the result that a deposit of mud was found on the bottom of the tank

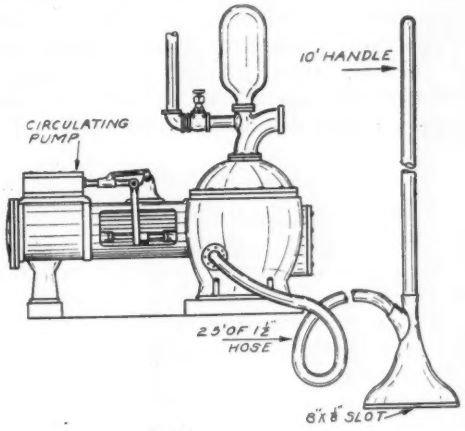


FIG. 1

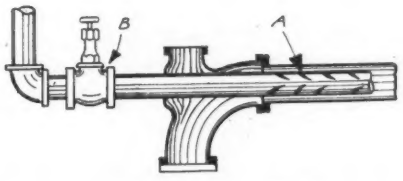


FIG. 2

FIG. 1. DIAGRAM SHOWING ARRANGEMENT OF SWIMMING TANK VACUUM CLEANER

FIG. 2. JET HEATER FOR HEATING WATER USED IN TANK

every morning. In the effort to minimize the amount of mud deposited, a filter was installed, using 2 bbl. of quartz crystals as the filtering material. This, however, did not help materially.

It was suggested that the mud be sucked out by means of an improvised "vacuum cleaner."

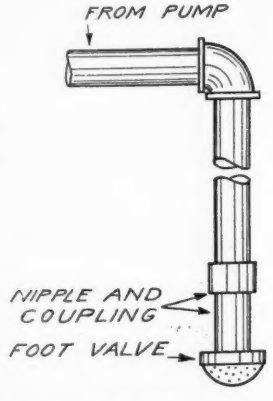
Connection was made with the suction side of the circulating pump, which pumped in the sea water, and a 1½-in. suction hose was run to the swimming tank and there connected to a suction piece, of shape similar to that of the ordinary vacuum cleaner tool. A 10-ft. wooden handle attached to this tool provided the means of moving it over the floor of the tank while the pump was in operation. The result was a clean bottom every day. Figure 1 shows the arrangement of the cleaner.

The sea water used in this tank had to be heated from 40 to 80 deg. F. This was done originally by using a surface condenser, but on account of continual tube trouble the condenser was discarded in favor of a jet heater of my own design, Fig. 2. A is a 1½-in. pipe in which crescent-shaped holes have been sawed, as shown. It is placed in the pump discharge below the air chamber and running a short distance into the discharge pipe.

When the pump is started, valve B is opened, admitting steam to the jet pipe, A. The steam, in condensing, creates a partial vacuum in A, which draws water in through the crescent-shaped openings. A slight chattering noise is audible, but the heating effect is good. It takes 6 tons of coal to heat one tankful of water to the required temperature. A. C. W.

When the Well Runs Dry

READING THE article by N. Ewing on page 1133, Dec. 15 issue, calls to mind an experience I had several years ago with a duplex steam pump used for pumping water into a tank from a well located some distance from the plant. One day this pump failed to deliver water to the tanks at times for some reason or other. In examining the pump a number of times, nothing was found wrong.



LOWERING THE FOOT VALVE BY MEANS OF A NIPPLE AND COUPLING

The well and suction pipe were then examined, but nothing was found wrong there. When one day the pump failed to pump water for a longer time than before, I got the idea that there was something wrong with the well, so I examined this and found that the water level was below the foot valve. To get out of the difficulty I lengthened the suction pipe by removing the foot valve, then screwing a short nipple and coupling pipe, as shown in the illustration. The foot valve was then screwed onto the nipple. This brought the foot valve below the water surface again, and we had no trouble with shortage of water for a few days. When the same trouble occurred again, the pump was examined first, but nothing found wrong; next, the well was examined and found to be entirely dry. In thinking the matter over, I came to the conclusion that the reason why the well ran dry was that some distance from the well a tunnel was made, the bottom surface of which was lower than the bottom of our well. Hence the water ran into the tunnel in place of the well. This also was the cause of the water going gradually lower in the well and the trouble we had with the pump.

I thought this would be of interest to other readers, as it may avoid much trouble and worry should there be similar trouble in the plant. First examine the well to see if there is sufficient water in it, before trying to find all the trouble in the pump, as I did. H. A. JAHNKE.

That National License Law

FOUR YEARS ago, I tried for and received my first license. Since that time, I have noticed with particular interest the lack of knowledge of steam engineering on the part of some men, particularly from states that require no license.

Recently I had occasion to visit a power plant in an unlicensed state. In the boiler room was a man of about 30 yr. who, I found after questioning him, knew as much about boilers as a 10-yr.-old child. All he knew was, shovel coal and put more water in the boilers if the whistle on the water columns blew. After much doubt of his ability, I decided to look the engine room over.

Upon my arrival in the engine room, I found the watch engineer adjusting the voltage. I soon entered into conversation with him, and as I had never seen this plant before I naturally began to ask for a little information regarding it. After a while, I was convinced that this fellow would not get by in the state from which I came. Of course he was all right as long as everything was running smoothly. Since my visit to this plant, I have found out that he has taken a steam and electrical course with a leading correspondence school; a very wise move, I think.

I wish to say here that I don't mean to insinuate that all engineers or firemen don't know their business. I think, and in fact I know, that the majority are willing to study and apply themselves to anything that will help them out in their chosen career.

It seems to me that if we had a national license law, life and property would be better protected as well as every man who is working for the betterment of himself and his interests. No man would be allowed to operate any piece of apparatus connected with a steam plant without having a certificate showing his proficiency.

DANIEL W. MAGUIRE.

RECENT ISSUES of Power Plant Engineering have contained a number of letters from subscribers dealing pro and con with the question of a national license law for stationary engineers. A majority of the writers seem to favor the enactment of such a law—though the question of its constitutionality does not appear to have been considered—and at least one writer cites as an example of the benefits to be derived, the comparatively high wages and excellent working conditions accorded to marine engineers under federal law. For the information of those readers who are not familiar with the laws and rules governing the issuance of license to marine engineers, the following, taken from the "Ocean and Coastwise Rules and Regulations of the U. S. Steamboat Inspection Service," which, with certain modifications pertaining to inland waters, are applicable alike to all marine engineers:

An applicant for license as chief engineer of ocean steam vessels shall be eligible for examination after he

has furnished evidence that he has had one year's service as first assistant engineer of ocean or coastwise steam vessels, or one year's service as chief engineer of lake, bay, or sound steam vessels, or two years' service as first assistant engineer of lake, bay, or sound steam vessels, or two years' service as second assistant engineer of ocean or coastwise steam vessels, or three years' service in the engine department of an ocean or coastwise steam vessel for license as chief engineer of ocean steam vessels of 500 gross tons or under.

An applicant for license as first assistant engineer of ocean steam vessels shall be eligible for examination after he has furnished evidence that he has had one year's service as second assistant engineer of ocean or coastwise steam vessels or one year's service as chief or first assistant engineer of lake, bay, or sound steam vessels, or two years' service as third assistant engineer of ocean or coastwise steam vessels, or three years' service as an apprentice to the machinist trade and engaged in the construction or repair of marine, stationary, or locomotive engines, together with one year's service in the engine department of ocean or coastwise steam vessels, or is a graduate from the engineering class of a nautical school ship together with six months' service in the engine department of ocean or coastwise steam vessels, or is a graduate in mechanical engineering from a duly recognized school of technology, together with six months' service in the engine department of ocean or coastwise steam vessels, or two years' service as a locomotive stationary engineer, together with one year's service in the engine department of ocean or coastwise steam vessels, or two years' service as second assistant engineer of lake, bay, or sound steam vessels, or three years' service in the engine department of ocean or coastwise steam vessels, for license as first assistant engineer of ocean steam vessels of 1000 gross tons or under.

For second and third assistant engineers of ocean steam vessels the requirements are not quite so great.

No person shall receive an original license as engineer or assistant engineer of ocean steam vessels who has not had the experience required by the foregoing section, or experience which is deemed by the local inspectors to be a fair and reasonable equivalent therefor. The examination for license as chief or assistant engineer of ocean steamers shall be such as to satisfy the local inspectors that the applicant is capable of meeting the requirements and performing the duties required by the grade of license for which he makes application. No original license shall be granted any engineer who cannot read and write and who does not understand the plain rules of arithmetic.

Boards of local inspectors, consisting of one inspector of hulls and one inspector of boilers, are stationed at various ports throughout the country and conduct all examinations within their respective districts, in addition to performing other duties in connection with the enforcement of the laws and rules governing the operation of steam vessels. Each local board makes up its own set of examination questions for each grade of license, and in so doing takes into consideration local conditions peculiar to the given district in which the board functions. An applicant for license must submit documentary proof that he has had the experience demanded for the grade of license he desires to be examined for.

That the above quoted law has proven of great advantage to marine engineers in general is a fact beyond dispute, but it would be a grave error to assume that all the advantages gained by marine engineers during recent years are attributable to no other cause; on the contrary, the fact that they are strongly organized, with farsighted and aggressive men at the head of their union or association has been the largest contributing factor in their advancement, and has in a large measure enabled them to dictate the terms of their employment.

With all due respect to engineering associations, and other similar organizations, membership in which, as a means of advancement, is advocated by one writer, it must be apparent to all who have given the matter thought, that no great change in the status of stationary engineers—as regards wages and working conditions, can be brought about solely through a policy of "advancement through education and legislation," at least not in time to prove of benefit to the engineers of today. While it is true that the constitution of the average labor union does not provide for an educational policy, it should be borne in mind that the real function of a labor union is to advance the economic rather than the educational interests of its members.

ROSS G. WILLOH.

Makeup Pieces for Flange Joints

I HAVE noted several times that certain writers for the technical journals recommend using wood wedge pieces between flanges on pipes which are out of line, and straight wood pieces between flanges when the pipes are too short. Such wood makeup pieces are all right on cold water or waste pipes, as far as preventing water leaks is concerned; but they should never be used on high pressure hot water or steam mains. Hot water or steam will swell the wood up much quicker than cold water would, thus softening it and reducing its tensile strength considerably. Twenty-five or 30 yr. ago, wood makeup pieces were often used, usually on pipes carrying low pressures, such as 60 to 100 lb. Even at that, I have seen some bad blowouts where they were used. The only excuse for using such makeshifts on high pressure mains is in cases where it is absolutely necessary to get some line in temporary operation.

When a pipe of large diameter is too short, or an angle is required different from the standard fittings, and there are no flexible fittings on hand, it is a simple matter to make either straight or wedge pattern pieces and get them turned out, in cast iron at any foundry, at small expense. Gaskets at each side of such pieces and placed between the flanges or fittings will make a permanent, safe piece of work.

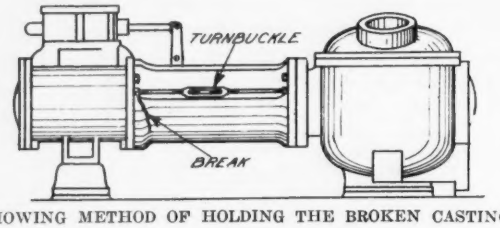
In the plant where I am engineer, we have a 12-in. main extending partly around a room having corners of odd angles. It was required that the pipe lie close to the wall and it was, therefore, necessary to use tapered pieces between the flanges. Wood pieces were carefully fitted into each joint to make a perfect fit. They were then taken out and calipered at four points on their circumference and a record made of the measurements. Castings were then made, these wooden pieces being properly prepared and used as patterns. The faces of the castings were then planed off until they were

reduced 3/32 in. on each side to allow for 1/16-in. rubber gaskets. The castings were then carefully calipered to note if they showed an exact reduction at each of the four points corresponding to the measurements taken on the wood patterns. At the smallest part of some of these irons the thickness was less than ¼ in.

How long would wood hold out on such a job? My advice to all engineers is to shun wood makeup pieces on pipes carrying liquid where there is both heat and pressure. JAMES E. NOBLE.

Quick Repair to Boiler Feed Pump

WE HAVE at our plant three independent boiler feedwater pumps and it happened that two of these pumps were down for repair, while the third was in operation, when this pump also broke down, breaking at the point shown in the sketch. The other two pumps required at least 2 hr. work, therefore we could not start them, so we had to act quickly.



SHOWING METHOD OF HOLDING THE BROKEN CASTING TOGETHER

We decided to repair the third pump in the following manner. We removed the tap bolts on each side of the center piece between the water and steam chamber and replaced them with long rods, a lock nut next to the flanges and a turn buckle in the center, thus drawing the center piece together at the broken point and at the same time connecting it with the water and steam chambers. This took about 10 min. and we were able to keep our boilers supplied with water. The pump is still running, but of course we will replace the broken part with a new one. JOHN A. KAGERHUBER.

Fuel Economy

WE ARE as far behind in one of the great and financially important dollar saving factors in the boiler room as it would be to attempt to place the feed water in a boiler without a feed water heater. The majority of our furnaces are taking air underneath the grates at 100 deg. F. instead of, as a rough estimate, 300 or 400 deg.; a tremendous loss, isn't it? I am well aware of the fact that numerous experiments have been tried along this line, in the nature of underground tunnels from the rear of the boiler setting to the grate bars and through the bridge wall, and other methods, all of which have proved to show either no efficiency gained or trouble from clogging up. To look the problem square in the face, however, from a standpoint of gain in efficiency, we must use heat units to heat this air that has already done its work in the boiler, and when we use the heat units while they are working in or under the boiler, we are robbing the boiler of results that it would obtain if they were not used in superheating the air. To overcome this feature, I would suggest that all smokestacks be equipped with additional stacks built around the original stack, ⅔ the height, and of such a diameter as would allow the proper amount of air to go down the stack, and be superheated for the furnace, being conveyed from the stack to the furnace by a separate breeching. If the draft of the furnace proved insufficient for proper combustion, that could be overcome by installing a suction fan in the hot air breeching to force it underneath the grates. This system with steel stacks should be a real money maker as an improved addition in equipment to the power plant. Where concrete stacks are to be contended with, the writer claims that the problem will work just as well with a few additional changes.

H. W. ROSE.

A Curious Cause of Pump Trouble

THE WRITER recently encountered a most unusual case of a pump knocking. The pipe line from the heater to the pump was of ample size; the head was about 5 to 6 ft. and apparently everything was in good shape, but the knocking continued. The springs were clipped off to reduce the force required to push the water through the valves, the pump was vented to the heater and the feed temperature was purposely cut down several degrees in order to assist, but the knock still persisted.

We were taking down the suction line with a view of installing a standpipe at the pump, when we discovered the source of the trouble. The suction pipe between the heater and pump had gradually accumulated a coating of soft scale, probably carbonate impurities, thrown out of solution because of the heating action in the heater, until the cross-sectional area of some ports of the pipe had been restricted to the extent of 50 to 60 per cent, thus hindering the flow of water to the pump. The pipe was thoroughly cleaned out and provided with flanged connections so that it could occasionally be quickly taken down and cleaned, and the difficulty was entirely removed. M. A. SALLER.

Meters for Producer Gas

IN THE Dec. 1 issue there appeared an article under the heading, "Measuring Producer Gas," which seems to the writer to be very misleading. This article states that in the measurement of producer gas there are two methods available—the pitot tube and the standard orifice. One draws the conclusion from the article that these two types of meters are the only types available for this class of service. This conclusion is not correct and, with all due regard to the merits of the types mentioned, they do not represent general practice in this particular field in this country. The Venturi, the Thomas electric, the rotary and the revolving drum meters are the devices generally used in the measurement of various kinds of producer gas.

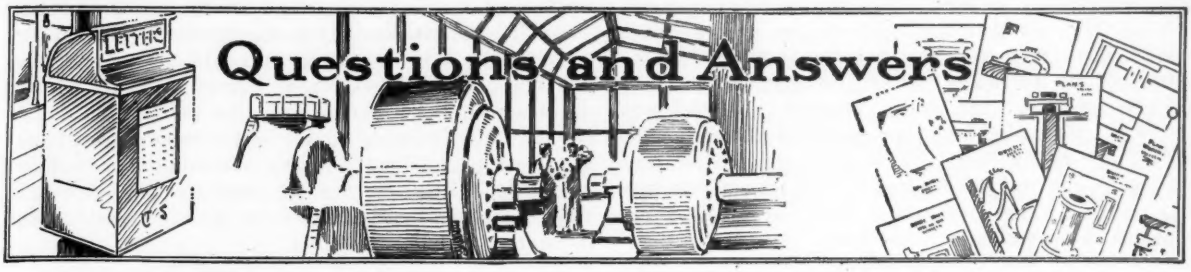
CHAS. G. RICHARDSON.

THE SWEET YOUNG THING was being shown around the power house. One of the main fuses blew with an unusually loud report.

"My goodness! what was that?" asked the Sweet Young Thing.

"A short," replied the guide.

"Really, I'm so glad it wasn't a long."



A Belt Problem

WE HAVE a 14 by 42-in. single eccentric Allis-Chalmers Corliss engine with 10-ft. flywheel, 16-in. face, running 90 r.p.m., which drives a Westinghouse generator, 125 kw., which has a 16½-in. pulley 20-in. face, this being driven by a 16-in. double-ply leather belt and the distance between centers being 30 ft.

We are having considerable trouble with the tight side of belt being on bottom which jumps and twists when this engine reaches about ¾ load, and it is impossible to put a larger load on. The jumping is also noticed by a flickering of the lights and is caused by every half stroke of the engine. The valves have just been set by a competent man, and the engine seems to be in good running shape. We are carrying 125 lb. gage steam pressure. We have tried lowering this pressure and also loosening and tightening the belt, which does not seem to help matters much.

I would like to ask some of the readers of this magazine to give their opinion and remedy of this jumping and twisting of the tight side. E. R. B.

A Peculiar Accident

I HAD a rather unusual accident with the relief valve on my air system. The 2-in. relief valve was screwed into a tee as shown in Fig. 1 and set to blow off at 108

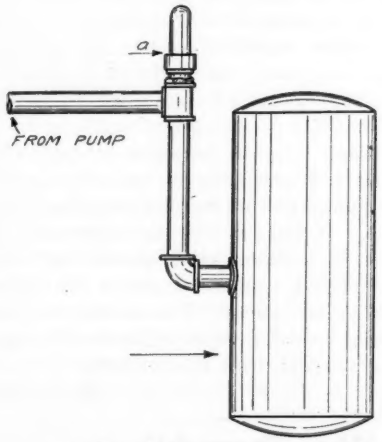


FIG. 1. LAYOUT OF THE PIPING

lb. It was in good working order, as it generally blew off several times a day. The last time, however, though it blew in the usual manner, the gas issuing from it ignited and burned with a flame 6 ft. high, until there was no pressure in the tank. The valve, by this time red hot, then blew into several pieces, as in Fig. 2. The discharge pipe and tank were not above normal temperature, and the air oil I use has a flash temperature of 450 deg.

My opinion as to the cause of the accident is that the machinist, in filling a blow-torch, spilled a quantity of gasoline on the floor near the air compressor suction; that gasoline vapor was sucked in by the compressor and compressed, and that when the valve blew off this vapor

FIG. 2. PARTS OF THE EXPLODED VALVE

was ignited. The suction is being piped to the outside of building. I would like to hear other opinions as to the cause of the valve exploding. R. B. R.

Why the Short Stroke?

I NOTE that on page 158, Jan. 15 number, P. W. M. wants to know, why the short stroke? Possibly I can help him to solve the problem.

First of all, I think he has worked on the wrong end of his pump, to remedy the trouble. I do not know whether it is an old pump or a new one, so I cannot state positively just what remedy to apply. I would advise first, that he set his steam valves as they were when they left the factory. When he has done that the following defects should be looked for: True up piston rods if worn. Clean out stuffing boxes and put in new packing, so that the piston rods can run in perfect line. In case of an old pump, possibly the water cylinder is worn in the middle so the packing binds on the ends, as the piston travels over. The suction valves may be cracked, or warped, and do not seat so as to hold the water. The tension on the spring may not be sufficient to seat them tight. The discharge valves may be warped or cracked.

The packing may be too small and the water passes around the piston instead of into the discharge pipe.

The packing may be worn. Possibly the follower nut is not up tight, so that the follower tips over a little; what I mean by that is, the shoulder on the rod at the bottom of the thread is too long so that the nut does not come up tight against the follower. He also says he has a 1¼-in. discharge pipe, which is too small. Put a 2-in. pipe in for discharge. I would also advise, if an old pump, putting new linings in the water cylinders. I think if the suggestions given above, are followed out, his short stroke will end. M. S. W.

It appears to me that if one side of the pump referred to by P. W. M., in the Jan. 15 issue, operates smoothly while the other side works with a jerky motion and causes hammering in the feed line the trouble is likely due to defective valves in the water end, or some form of obstruction in the suction line.

Due either to friction or the lodgement of something on the seat, the discharge valves may be held open on one end. Sometimes a sharp hammer blow will remedy this defect, although it is more advisable to remove the valve chamber cover and in that way locate the actual cause of the trouble.

Slamming may also be due to a leak in the suction system in either valves or joints, or to a leak in the piston packing. Frequently stiff inlet valve springs cause this trouble.

When starting up, air in the pump may cause it to slam, the proper remedy then, of course, being to prime the pump and suction line. D. H. R.

In answer to P. W. M.'s question in the Jan. 15 issue, I will say that it is impossible to adjust the steam valves so as to overcome the jerky motion.

The remedy is to have the water valves and valve seats turned down. The pump will then give better satisfaction and pump more water, and at a higher temperature, with less steam.

This pump has evidently been in use for some time.

C. Brazil.

I would like to submit this answer to P. W. M.'s question as to what makes his pump short stroke.

If his steam valves are correctly set, I should advise him to go over his water end, as I am sure he will find his trouble there. I have handled several makes of pumps and have found that nine out of ten times the trouble of short stroking is due to trouble in the water end. His valves may not seat properly on the valve seats and need regrinding or the springs may have more tension on one side than the other. Again, the packing may be too hard or drawn up tighter on one rod than the other. Enough water might be leaking past one piston or flange to cause short stroke. I think if P. W. M. will go over his pump in this manner, he will cure his trouble in a short time. D. G. S.

With regard to P. W. M.'s inquiry, I would suggest that he make an examination of the water end valves of his pump, and the water pistons or flanges as well. There may be, and probably is, a surging back and forth of the water, owing to defective valves or pistons, or perhaps both. Sometimes the piston rod packing being screwed up too tightly will cause a pump to act as described by P. W. M. It would be interesting to learn just what he has done about the trouble, so that other readers who may some time run into the same thing, will know what to look for, and how to remedy it.

In conclusion, I would say that there is no doubt about W. N. L. being correct in his answer relative to the lower part of the Manning boiler, and the stresses involved. The difference in plate thickness between upper and lower parts, is at least one evidence that the method of calculation is correct.

Charles J. Mason.

In answer to P. W. M.'s inquiry as to his pump working with a jerky motion on one side and causing a hammering in his feed line, I will say that we had the same trouble with our pump, and when we examined the valves and seats we found they did not seat properly. The water worked back and forth through the valves at each stroke, wearing hairline grooves on the bottom of the valves and on top of the seats. The water working back and forth through these valves caused the check valve in the feed line to hammer.

We faced off the valves and turned down the valve seats until these hairline grooves were gone and the valves seated tight. Since then we have had no trouble, and do not need to run the pump nearly as fast as before. Leslie Klock.

A boiler feed pump should always be so connected that its supply of water from a heater or tank is from 2 to 5 ft. above the pump, and the suction line should be the size for which the pump was built. If the supply of water is any distance from the pump, the suction line should be increased in diameter above its original size from ½ to 1 in. in diameter.

Suction lines should not be allowed to corrode or clog up with scale or any other foreign matter, as it reduces the supply of water to the pump, which will cause it to hammer the same as an air leak in the line. If the supply of water for the pump is an open heater and the water allowed to be heated over 210 deg. F., it will cause hammering. Poorly seated valves will also produce this trouble in the water end, especially if the lines are in bad shape. If the steam valves are set correctly, this pounding or knocking is caused by trouble in the water-end of the pump. It must be borne in mind that hot water, to be worked satisfactorily, must flow of its own accord to the pump, and in the quantity that the pump has to handle. If not, it will cause pound. If the pump handles cold water, it is almost too much to expect it not only to put the water in the boiler, but to pull it up to the pump. The distance of location of the discharge end of the pump has no bearing whatever upon the irregularities encountered.

H. W. Rose.

Water Rates of Engines

In the issue of Dec. 15, page 1133, we note that you give a resume or comparison of the various types of Corliss valve, high-speed engines of from 150 to 200 hp.

We believe that your advices as to the steam consumption of a standard slow speed Corliss engine running noncondensing at from 100 to 120 revolutions are correct.

We assume that in giving the steam consumption you have, you are assuming atmospheric exhaust and a steam pressure at the throttle of 140 to 150 lb.

In reference to the economies which you give for the so-called four-valve or high speed Corliss nonreleasing, noncondensing engine, of from 26 to 28 lb. per indicated horsepower, we would like to know your authority for such a statement. We know that your information is either incorrect or otherwise in error. We are daily coming in contact with engines of this type, of such well-known makes as the Ridgway or the Erie-Ball, where their steam economies under the conditions which the writer has mentioned in the foregoing, will run in the neighborhood of 22 lb. per indicated horsepower-hour.

L. E. POLLARD CO.
By L. E. POLLARD, Pres.

A. The figures published in the Dec. 15 issue were taken from a reference table which was published on May 15, 1918, credited to the Nagle Corliss Engine Works. The figures given were based on an initial pressure of 100 lb. gage. Gebhardt in "Steam Power Plant Engineering," page 422, 5th ed., gives figures stated to be "Guaranteed performance of a well known line of high grade piston engines." For a medium-speed four-valve non-condensing engine of 200 hp. operating at ¼ cutoff and an initial pressure of 130 lb. gage, the water rate at full load is given as 23.45 lb. This would seem to compare favorably with the figures published.—EDITOR.

Steam Engine Indicator Diagrams

REFERRING TO the Jan. 15 issue, I note the question by J. A. G., page 158, relative to a pair of indicator cards taken from a tandem compound Corliss engine exhausting into a low-pressure turbine. There is really nothing materially wrong with those diagrams; but if minute faults are to be pointed out, they are: Too slow opening of the exhaust valve, at that end of the high-pressure cylinder represented by the left-hand diagram. Next, the receiver pressure is too high, as evidence by the needle points in both the low-pressure diagrams at the exhaust ends. A lower receiver pressure will remedy this fault, and therefore admit of the steam entering the turbine at a little higher pressure than it evidently does at present. The benefit will be a slightly greater range of expansion in turbine, where it should be, rather than in the low-pressure cylinder of the reciprocating engine.

With regard to the low-pressure diagrams, the steam lead is a little late at both head and crank ends, particularly at that end represented by the right-hand diagram. This fault is shown by the rounding corners. A small adjustment of the valve arm rods to the wrist-plate will remedy this slight fault.

CHARLES J. MASON.

THE INDICATOR diagrams submitted by J. A. G., could be improved a little. Call left-hand diagram the head end, the right-hand one, the crank end. The high pressure head end exhaust valve opens too late, giving the card the well known "slipper" effect. The compression on the crank end is considerably more than the head end; it could be cut down.

The low-pressure steam valve on the crank end ought to open a little sooner, as the corner of the steam line is too rounded. The cutoff on this end could be lengthened also, balancing the load. The low-pressure cylinder is doing about 13 per cent more work than the high; I would change the receiver pressure. But it might be that the engine runs better as it is. I would examine the valves for leakage, especially the crank end low-pressure exhaust valve. TOM JONES.

I SHALL TREAT simply upon the larger defects which may be corrected without a shut-down of the engine. One of the principal corrections in the valve setting of this engine should be to relieve the high-pressure cylinder of its overload by balancing the load as nearly equally as possible between the high and low-pressure cylinders. I would close both exhaust valves on the low-pressure cylinder to a considerable extent. It is extremely hard, however, to give any exact figures for the setting of these valves, owing to their evident condition, which needs no further argument than the information that this engine has been in operation day and night for the past 22 yr. Quite a saving would be secured if this engine could be shut down and thoroughly overhauled, relined possibly, new bearings, new valve stems and valves, seats worked over, cylinders re-bored and new rings fitted.

In referring to the high-pressure diagrams, it may be stated that the live steam valves may possibly have a shade too much lead and the compression is too low. The main point, however, is to get the load more equally divided between the high and low-pressure cylinders. The live steam valve on the crank end of the low-pressure cylinder appears to be opening a shade late.

H. W. ROSE.

Boiler Pitting Difficulty; Turbine Lubrication

ANOTHER LETTER; this one relative to E. R. Rivers' and F. A. Lekava's communications which appear on page 161, Jan. 15 issue of Power Plant Engineering.

First, with regard to the boiler pitting difficulty, I have found from actual experience that pitting may be arrested by coating the surface of the metal where pitting has begun with a thick red lead paint, which means a mechanical moisture or preparation of red lead and boiled linseed oil. These two substances together make a coating that sticks much better than the boiled linseed oil will alone. There is absolutely nothing injurious in the combination; on the contrary, it is one of the best preservatives against corrosion, either externally or internally. I have used it in boilers under my charge and none of the insurance companies or authorities in the Police Department ever made any complaint against its use.

Next, with regard to the use of cylinder oil on turbine bearings to keep them cool, there are on the market oils specially made for steam turbines. These oils easily and quickly separate from water and other impurities that may be picked up in the oiling system. While cylinder oil may, and in Mr. Lekava's case did, cool off a hot bearing, it depends upon whether that oil is a straight mineral or a compounded oil, as to whether any further trouble occurs. If it is a compounded oil, it will not readily separate from water, but will emulsify with it, and the more easily pick up any other impurities

in the system. Eventually a sludge will form, and then the real trouble will begin. For the oiling system of a steam turbine, a straight mineral oil, only, should be employed. It should be of such a body as to be of the correct viscosity at the temperature it has to encounter in the bearings, and consideration must be given to those bearings that are to endure induced heat, which is somewhat different from the heat of frictional resistance. Instead of continuing the use of the cylinder oil, therefore, it might be well for the correspondent to look into the matter along the lines suggested. The relatively small quantity of oil used in 2 or 3 hr. and that being repeated, may be enough to contaminate the whole system —if the oil used is compounded with animal or vegetable fats. CHARLES J. MASON.

Some Miscellaneous Questions and Answers

WHAT IS the ignition temperature of anthracite coal?

2. How can hydrogen be burned so as to form water and thus produce 62,000 B.t.u.?

3. Are steam lap and outside lap the same?

4. What does the term "backlash" mean as applied to a steam engine?

5. How is the vacuum line drawn on an indicator card when running condensing, and also when running noncondensing?

6. How and of what are labyrinth packing rings made?

7. What is direct radiation?

8. What is indirect radiation?

9. What is meant when an engine is said to use, say, 1000 lb. of steam per hour? How many pounds of water would that be?

10. What is the trade name or general name for a jet condenser of the high (34-ft.) type, as compared with a condenser that is built low down and sometimes connected with the vacuum pump, the condenser and the pump being built in one unit?

11. What is meant by "shifted cores" of a pump?

12. Are there any condensers made that do not require any vacuum pump?

13. Which system of heating is the most effective—the one-pipe system or the two-pipe system, the radiators being the same size in each system?

14. What is meant by equivalent evaporation?

15. What are the dry products of combustion?

16. What is volatile matter.

17. Is there any other way to change the speed of a Corliss engine except to change the size of the governor pulley or its driver?

18. When using a draft-gage made from a glass tube bent in the shape of the letter U and an ordinary carpenter's rule is put between the two legs in order that the difference in height of the water in each of the legs may be easily read, and if the difference in height of the water is 2 in. (actual measurement), does that indicate that the draft is 2 in. or ½ of 2 in. or 1 in.?

19. Considering a Corliss engine, if the rocker arm did not vibrate equal distances each way from a vertical position, what would be the result and what harm would it do?

20. Will lengthening the cutoff on each end of a Corliss engine change the power of the engine? If so, in what proportion, or how is it figured?

21. When finding the area of an indicator diagram in square inches by the use of a planimeter, the pointer of the planimeter being moved over the lines of the diagram in the direction of the hands of a watch, then this reading multiplied by the scale of spring used, and dividing the product by the length of the diagram in inches equals the mean effective pressure in pounds; now, should the area between the line of back pressure and the atmospheric line be subtracted from the actual area of the diagram in order to get the actual, exact mean effective pressure?

22. Will a "shot" of water hurt a steam turbine? In other words, will priming injure a turbine as easily as it will a reciprocating engine?

23. Is there any instrument or device that will record the CO and CO_2 as they are formed in the furnace and run continuously for 24 hr. so the per cent of these can be checked with any day previous? If so, please explain.

24. Where should feed-water enter in a water tube boiler?

25. In horizontal tubular boilers having three courses of sheets, why is the middle sheet fitted between the two end sheets?

26. When, where and how are stays or braces subjected to compression instead of tension?

27. How may the valves of a Corliss engine be tested without the use of an indicator to ascertain whether they leak or not? W. L. S.

ANSWERS

THE IGNITION temperature of anthracite coal, which is composed largely of carbon, is 750 deg. F.

2. If hydrogen is burned in pure oxygen, water is formed and the heat produced is in the neighborhood of 62,000 B.t.u.

3. Steam lap and outside lap are the same in an engine of the ordinary slide valve or piston valve construction where the steam is allowed to enter the cylinder past the ends of the valve. Where the steam enters the cylinder past the center of the valve, the steam lap is in that case an outside lap.

4. "Backlash" as applied to a steam engine or any other form of machinery refers to the lost motion in various bearings due to wear. If the engine is pushed forward a short distance and the flywheel then moved backward a few degrees, if there is any wear at all, it will be noted that the flywheel and crankshaft are the only parts which move, the connecting rod and valve gear remaining stationary.

5. When an engine is run condensing, the vacuum line can be drawn on an indicator card by connecting the indicator with the exhaust line instead of the cylinder. When running noncondensing there is no vacuum, and therefore no vacuum line can be drawn.

6. Labyrinth packing rings are used in places where friction is desired to be as much as possible eliminated. They consist of a number of collars turning on a revolving shaft, such as the turbine shaft, which fits with a certain amount of play, into grooves turned in the turbine housing. The principle upon which they work is that steam in passing through the various paths en-

counters so much friction that very little steam is allowed to pass into the atmosphere.

7. Direct radiation refers to that arrangement of radiation in a heating plant where the radiators are placed in the room to be heated.

8. Indirect radiation refers to that type of steam heating plant wherein the heating elements are located in the basement, the heat being carried to the various rooms by means of heated air.

9. An engine using 1000 lb. of steam per hour uses that amount of steam which was evaporated, theoretically from 1000 lb. of water.

10. The correct name for that type of jet condenser employing a 34-ft. water column is the "barometric" condenser.

11. The "shifted cores" of a pump possibly refers to the defect in the casting where the cores which form the steam passages are shifted out of their proper position.

12. The barometric condenser requires no vacuum pump. It does, however, require an air pump to remove the air and noncondensable gases.

13. Whether the one-pipe or the two-pipe system is the more effective depends to a great extent on the size of the plant. In small plants, the one-pipe is more universally used than the two-pipe system.

14. Equivalent evaporation is a term used in the rating of steam boilers by their evaporation capacity. Where the steam is evaporated at, say, a temperature of 300 deg. F., the amount of heat put into this steam would evaporate a greater amount of steam at 212 deg. F. and atmospheric pressure. Equivalent evaporation is the capacity of the boiler expressed in capacity at 212 deg. F. and atmospheric pressure.

15. The dry products of combustion are the gases and other products other than water which are evolved as a result of the burning of any substance.

16. Volatile matter is matter capable of being vaporized.

17. The speed of a Corliss engine can be changed by shortening or lengthening the rods connecting the governor to the valve gear.

18. When a draft gage of a type which you describe is used, the difference in the height of the water is the measure of the draft in inches, in your case 2 in.

19. If the rocker arm of a Corliss engine did not vibrate equal distance on each side of the vertical position, there would be little effect on the action of the valve if the arm were rather long. In the case of a short arm, however, there might be considerable distortion of the valve diagram.

20. Lengthening the cutoff in each end of a Corliss engine will increase the power of the engine in about the same proportion that the cutoff was increased.

21. A planimeter designed for that purpose measures without any adjustment the average mean effective pressure in pounds of an indicator diagram.

22. Priming is more likely to harm a steam turbine than a steam engine, as the former is of much more delicate construction.

23. There are a number of CO_2 recorders on the market which make periodical records of the amount of CO_2 in the flue gas at intervals of anywhere from 10 min. to an hour depending upon the speed to which they are adjusted. See the Jan. 1, 1920, issue.

24. In a water tube boiler, the feed water should enter the water drum at the front end, the pipe passing through the water a sufficient distance to heat the water partially before it is allowed to enter the boiler water.

25. In horizontal tubular boilers, the middle sheet is fitted inside of the two end sheets merely as a matter of convenience in construction.

26. The stay in a boiler would be subjected to compression instead of tension, if due to some cause it had been stretched beyond its ultimate strength and failed to return to its original length.

27. The steam valve in a Corliss engine may be tested by putting the engine in such position that the valves are closed. When the steam is turned on, if there is any leakage, it may be seen by opening the indicator cock. The exhaust valves may be tested for leakage by putting the engine in such a position that they are closed. The steam valves are then opened and any leakage will be noted in the exhaust pipe.

Refrigeration Questions and Answers

How many lineal feet of 1, 1¼, 1½ and 2-in. pipe each, will make or are equal to one ton of refrigeration?

How many feet of such will be required per cubic foot of space to be cooled? J. D. B.

A. To secure the refrigeration effect equivalent to one ton would require approximately 200 ft. of 2-in. pipe or 320 ft. of 1-in. pipe. Each cubic foot of space to be cooled would require from 5 to 10 ft. of 1-in. pipe. These figures are only very rough approximations, as, in order to give you accurate figures, it would be necessary to have much more data than you give.

Need of Proper Valve Springs

In a boiler-feed pump handling exceedingly hot water, should the stronger springs be used on the suction or the discharge? In fact, will a stronger spring do any good? H. S.

A. In a feed pump which handles very hot water, the strength of the springs on the inlet valves should be just sufficient to close the valves when the piston has finished the suction stroke.

If this spring is too strong, it will allow the piston to create a partial vacuum with the effect that the water will have a tendency to boil, in which case the cylinder will be handling steam or vapor instead of water.

We believe that if any changes are made the better one would be to put weaker springs on the suction valves.

Calculating Power Requirements

Will you please advise me as to the size of oil engine; that is, number of horsepower, required to pull a 10-kw. generator and a 1½-ton ice machine?

How many 110-w. lamps will such a machine be capable of supplying with current? F. R. T.

A. The approximate power required to drive a 10-kw. generator and a ton-and-a-half ice machine is 15 hp. A 10-kw. generator will furnish electricity to light ninety 110-w. lamps.

Correction Note

The denominators of the fractions in the formulas on page 210, Feb. 1 issue, should have been 33330 instead of 3333 deg. as printed.

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Getting a License Law

For the past few months, a discussion has been running in the columns of Power Plant Engineering regarding a National Engineer's License Law. The editors have so far taken no part in this discussion, preferring that those in the field should first express their views. Now, however, that those who have so desired have had an opportunity to present their ideas to our readers, it seems wise that a short summary should be made of the features desired in such a law, also a suggestion as to what course to follow to obtain the results which are sought.

The first condition which must be faced is the fact that a national law regulating the licensing of engineers is contrary to a number of underlying principles of our Government, principal among which is the right of individual states to enact laws regulating affairs which do not in any way affect the health or safety of residents of other states or discriminate against their property. This, therefore, eliminates the consideration of a national law but does not prevent the engineers of the country from securing laws in the various states which have all the desirable features of a national law modified to suit local conditions. Thus we would have laws which are fundamentally the same, so that a license in one state could be recognized in another, a custom which is now practiced with teachers' certificates, without the necessity of a formal examination.

At the present time, a committee appointed by the Engineering Council is recommending a uniform state registration law for mechanical, electrical and civil engineers, architects and surveyors along the lines suggested above. This action has been precipitated by the adoption in several states of laws which are somewhat conflicting and to prevent any further complications a uniform law is proposed.

A similar condition now exists in regard to operating engineers. The laws in the various states which require licenses differ so greatly that recognition of a license is not universal. The practical course of procedure for the operating engineer differs from that of the consulting engineer for the reason that operating engineers usually confine their activities to plants in one locality while the consulting engineer may have clients in several states. So the operating engineer is affected only by the laws of his own state and is only passively interested in the laws of other states. For this reason, few would concern themselves with problems which they consider rightfully belong to others. The states must therefore work separately, but a central committee could be formed to draw up a pattern for those states which have not already passed laws covering engineers' license.

The most logical procedure would be to work through all operating engineers' organizations of the state, particularly those of national scope, which would lend weight in securing state enactment. A good, live publicity committee to carry on an educational campaign in all available publications of the state for a year or so prior to the time when the bill is to go before the legislature will probably do more than any other one thing to stimulate action on the part of the law makers.

The safeguarding of life, health and property are the only bases for the enactment of a state law governing

the licensing of engineers. That a license law of the proposed character will obtain these results must be driven home to every voter. Opposition may come from stand-pat plant owners and incompetent engineers. Their arguments can be met by information collected in states where license laws now exist.

Summarized, the ideas of those who have discussed the question are as follows: A new national organization, composed of stationary engineers, firemen and oilers, to work for license laws and the betterment of all workmen in the field; government control, which of necessity must be confined to the various states; central examining board, also confined to states; licenses good in all states, which could be accomplished, if state laws and examinations were uniform throughout the country; graded licenses preceded by apprenticeship; guarantee to employers of fitness of men holding licenses.

All of these provisions could be worked out in committee when once the medium of societies has been established. This fact must not be forgotten, a Federal License Law is impossible, but all its benefits can be obtained through state laws.

Power Plants and Automobiles

As civilization advances, the call upon our natural resources increases and these resources consequently become depleted. During the past 20 yr. the rapid increase in the number of automobiles using gasoline as fuel has caused an alarming reduction in the oil reserves of the country. This supply can, of course, never be replaced and should, for the benefit of humanity in future generations, be conserved as far as possible.

According to data from the U. S. Geological Survey, compiled in 1917, at the present tendency in the use of petroleum the estimated supply in the United States will be exhausted by 1930. It is, of course, altogether likely that other sources of supply may be discovered; but the commercial end is apparently in sight and before many years the automobile industry will be clamoring for a substitute for gasoline to run cars.

For the conservation of natural resources the use of alcohol is probably the most logical solution to the problem of fuel for motor cars, as the material used for its manufacture can be grown in our agricultural districts in quantities to supply the varying demands. At present, however, the cost of denatured alcohol, the lack of facilities for making it in sufficient quantities and the necessity of redesigning the engines are obstacles in the way of its adoption.

Another and probably the most immediate solution is the general use of electric motor cars and trucks. This means of driving has been proved a success and economical, so that no great amount of development work is necessary. The greatest disadvantage of the electric car is the lack of general facilities for charging storage batteries, which is a problem for solution by power plant owners.

Due probably to the apparent preference of automobile drivers for gasoline cars, the power plant industry has done comparatively little toward the development of this field for the use of power, which is sure to broaden as the reserve supply of petroleum in the country decreases.

Any power plant that can furnish direct current for charging storage batteries can be used in this work and for the sake of conserving the oil supply, the power plant and automotive industries should work out plans for bringing electric autos into more general use as a replacement for the gasoline cars.

Central stations have not neglected the field entirely; but, as a rule, these furnish alternating current and require a rectifier for the charging of storage batteries. This arrangement is costly for private garages and extensive general service has not been established. The field is, therefore, practically open to the direct current power plants of the country. Isolated industrial and office building plants could readily perform this service and at the same time improve the economy of the plant by increasing the load factor and steadying the load.

Investing in Universal Training

While information from Washington indicates that opposition to the universal military training program as embodied in the army reorganization bill recommended to the Senate is not as strong as heretofore, there is still possibility of defeat. And even though the measure should pass the Senate, the fate of the bill in the House is still in doubt.

The benefits to be derived by the individual from universal training are hardly to be questioned. In fact, every man who was placed in training during the World War will be forced to admit that he left the service a far better man, both physically and mentally than before entering upon the training period. And the same result will follow universal military training especially if the program includes work along vocational lines.

The primary and foremost objection emanates from those members of our Congress who, according to one of them, "fear that universal training would add a crushing load to the burden of taxation notwithstanding the Senate Military Affairs Committee's assurance that the annual cost would be about $131,000,000." This is a small expenditure in comparison with the outlay necessary to maintain a regular or standing army and for insurance against possible future wars. Just what the late war has or will ultimately cost the United States is difficult to state, but a safe guess is $30,000,000,000. From a purely financial consideration of the question, this money has been expended without appreciable return. If, however, due to a system of universal training the respect of other nations for the United States had been such as to preclude provocation and consequent entry into the conflict this money might have been saved or expended for construction purposes and made to bear interest which at a 6 per cent rate would have amounted to $180,000,000, or $49,000,000 in excess of the estimate of the Senate Military Affairs Committee. It is evident, therefore, that while perhaps the initial expenditure required for the installation of a system of universal training may add slightly to our present taxation, ultimately such an investment will not only benefit the country financially, but will be returned in the form of a real blessing to its people in the form of assured peace and continued prosperity.

A Flue Point for Boilers

ONE OF the most common causes for locomotives being so frequently in the round house, is failure of tubes, or leaky joints. It is not unusual to have to re-roll or calk flue tubes at the firebox end after a very few trips. The average life of locomotive flue tubes is from 6 to 15 mo.; the feed water has much to do with the length of this period. To put in a new set of flues, or repoint the old ones, costs about $150. When the time lost is considered in connection with the cost of keeping tubes in good condition, it will be seen that this item of expense is an important one to the railroads.

As a result of study of these conditions, Charles S. Coleman, of Los Angeles, has developed a new type of flue point, that is to be welded onto the flue at the firebox end. This device is at present undergoing tests by one of the Western railroads, with good results.

The new flue point is made about two and one-half or three times the thickness of the flue tube of either steel or copper, and is turned down at the tube end to a shrink fit in the flue tube, as in Fig. 1, for steel, or tapered as in Fig. 2, for copper points. Space is

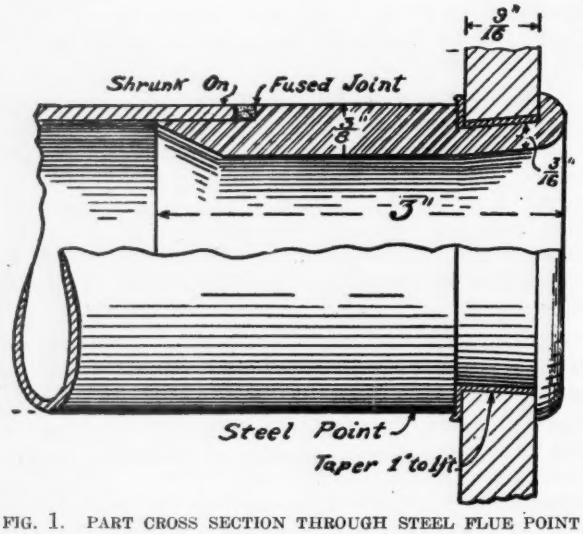

FIG. 1. PART CROSS SECTION THROUGH STEEL FLUE POINT

allowed between the end of the tube and the shoulder on the flue point for welding the two parts together. A special tube plate is required, with holes tapered 1 in. to the foot, the largest diameter at the firebox side. The flue point is turned down so as to form a square shoulder, which butts against the water side of the tube plate.

With steel points, copper ferrules are used, as with ordinary tubes, and the positive grip between the shoulder and the bead assures a positive contact between the ferrule and tubeplate in spite of expansion and contraction of the tube. This construction is shown in Fig. 1. With copper points no ferrules are used, the point being merely expanded into the tube plate. Figure 2 shows a copper fluepoint before expanding and beading.

Under test the welded joint has been shown to be able to stand a tensile strength of over 52,300 lb. at which tension the 2¼-in. tube, to which the point was welded, failed.

In addition to eliminating practically all leakage, the new point practically doubles the life of the flues. The thickness of the point provides reinforcement at a part which is particularly vulnerable to corrosion, due in part to the deposit of sediment which finds a ready foothold in the sharp corner, between the tube and tube plate.

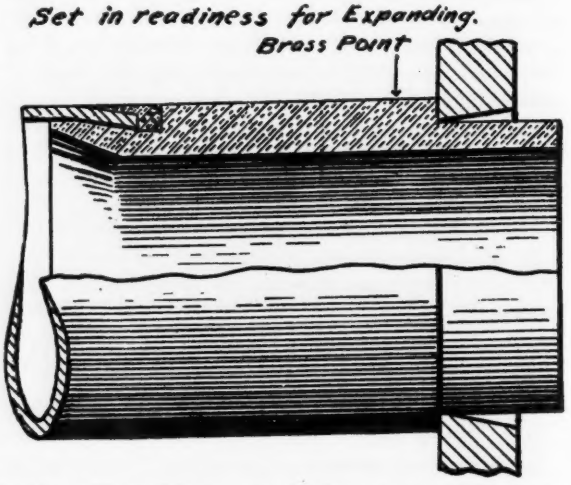

FIG. 2. PART SECTION THROUGH COPPER FLUE POINT BEFORE ROLLING AND BEADING

Although a power plant boiler is, as a rule, operated under less strenuous conditions than a locomotive boiler, there are nevertheless plants in which this or a similar type of flue or tube point would considerably lengthen the life of the tubes, and reduce loss from leakage.

Executive Training for Engineers*

BY MILO S. KETCHUM

THE successful engineer must not only have a thorough engineering training, but he must be trained to know men; must not only know how to design or to build, but must be able to impress others with his ability. In administrative positions, the ability to select subordinates is a prime essential. More engineers fail in administrative positions due to their inability to select men than to any other one thing. As a class, engineers are prone to judge men too much on their technical ability alone, and give too little attention to those qualifications and characteristics in men that make it possible to use technical knowledge. A man with a disagreeable disposition ordinarily has no opportunity to use his technical ability except in a very inferior position. One of the most important advantages gained from technical education is contact with other men and an appreciation of the value of human engineering. Of all the materials with which an engineer has to deal there is none so difficult to handle and control as human material.

"THOSE who flash suddenly into the limelight don't always stay. But sticking ability usually goes with those who climb step by step."

* From an address before the Engineers' Club of Philadelphia.

National Public Works Department Assn., Second Convention

NINETY-FIVE delegates representing societies with a membership, eliminating obvious duplication, of 90,000 met in Washington, Jan. 13 and 14, at the Willard Hotel, for the purpose of securing favorable action by Congress leading to the establishment of a Department of National Public Works, for which purposes under its articles of organization the association has been formed. The work of the new department as planned would be to take over the engineering and construction work of all other departments and put it all in charge of a cabinet officer who by education and experience is qualified to supervise the work of the entire department. Such an arrangement, it is believed, would result in great economy to the government.

Roll call of states on the status of the campaign showed much effective work had been done. It became apparent that the less crowded states had done the most successful work. Two states reported that their entire Congressional representation were committed to this measure.

The Jones-Reavis Bill was discussed and several objections raised to it, especially to the provisions transferring the Bureau of Education to the Department of Labor. The convention adopted a resolution to define its position on this subject and on other controversial sections, such as that providing for the transfer of the Forest Service from the Department of Agriculture. As these have nothing to do with public works, the association does not commit organizations affiliated with it to the support of this section of the bill, but leaves organizations and individuals free to discuss these matters with their representatives in Congress.

During intermissions delegates were given opportunity to visit their Congressmen and it was evident that a real interest is taken in the measure. The uniformly favorable reports from the state committees made the convention feel that real progress had been made and that the principal obstacle in the way was the inertia of men who should be actively supporting this measure.

Artificial Daylight Practically Achieved

A LIGHT has been perfected in Great Britain which is understood far to surpass any existing arrangement of artificial light, and to be the closest approximation to actual daylight ever accomplished.

The apparatus consists of a high-power electric light bulb, fitted with a cup-shaped opaque reflector, the silvered inner side of which reflects the light against a parasol-shaped screen placed above the light. The screen is lined with small patches of different colors, arranged according to a formula worked out empirically by Mr. Sheringham, the inventor, and carefully tested and perfected in the optical engineering department of the Imperial College of Science and Technology.

The light thrown down from the screen is said to show colors almost as well as in full daylight. A test was made with such articles as colored wools, Chinese enamels, pastels and color prints, each being subjected successively to daylight, ordinary electric light and the new Sheringham light. Under the new light delicate yellows were quite distinct, indigo blues were blue, cobalts had their full value, and violets lost the reddish shade which they display in electric light. A great future is expected for this invention in such uses as the lighting of show windows and art galleries, studio work of all kinds, dye-works, tea and tobacco blending, and many other industries. Color photography will also probably benefit. As is to be expected, a proportion of the illuminating value is lost in the process, and higher candle power has to be used, but 60-candle power bulbs were satisfactory for the experiments mentioned.—Anglo-American Trade.

Reducing Cost of Production

AMONG the conditions affecting the high cost of living is the high cost of production relative to which the Pratt & Cady Co. makes the following suggestion to manufacturers, which is equally applicable to engineers who draw up specifications for manufactured equipment:

"You are invited to join a movement to perpetuate the good work started by the United States Government, during the war, to reduce the high cost of production by standardizing manufactures.

"It is to the advantage of manufacturers to do all possible to discourage the use of special sizes or designs which, in most cases, vary only slightly from the standard goods shown in their catalogs. For it costs more money to manufacture 'Specials,' upsets manufacturing schedules, retards production and requires the time of labor which, in these days, is scarce and high priced.

"So why not urge your customers to use your standard goods when they order specials?

"And why not also follow the same course when you order goods?

"If every one of us would only work to the full extent of his mental and physical strength to assist in producing the things needed for the world, there would be boundless prosperity and enlarged production, and mankind in general would be greatly benefited.

"Efficiency to the fullest utilization of man's power to produce must be pressed on all of us.

"Let's all pull together to 'Take the Hobbles Off Production.'"

News Notes

A BILL has been introduced in the Kentucky state legislature providing for the creation of a Board of Boiler Rules to prescribe rules and regulations for the construction and use of boilers, which shall be uniform with other existing state rules, and as nearly as possible in conformity with the boiler code of the American Society of Mechanical Engineers. Rules requiring any changes in construction or material used shall go into effect 6 mo. after the bill is approved. The board is to consist of "four citizens of recognized knowledge of the construction and use of steam boilers" in addition to the chairman, who shall be, the Commissioner of Labor, or the Chairman of the Industrial Commission, the Com-

mission of Public Safety or the Department of Workshop Inspection, or of any other existing state board. Penalties are provided for violation of the rules.

To give every worker of the Morse Chain Co. who has been with that concern a year or more an annual dividend on his wages averaged as if invested in the company's business at the same rate as drawn by the stockholders on the company's investment, is one of the New Year's gifts announced to the 670 employes by Frank L. Morse, president of the company. Also the concern proposes to establish a fund for the purpose of installing a service store in the new service building to be erected by the corporation, where all employes may purchase goods at cost, as well as patronizing a cost service cafeteria.

A flywheel bursting recently at the plant of the Goodyear rubber shoe plant in Naugatuck, Conn., caused the death of Horace Higgins, seriously injured James Hanley and painfully bruised two other employes. A section of the wheel, hurled with terrific force, crashed through the wall of the building. The cause of the accident is being investigated.

Celite Products Co., New York, announces the death, on Jan. 15, of David L. Collins, of that company.

U. S. Civil Service Commission announces an examination Feb. 24 for technical instructors. Vacancies at Ordnance Schools or in the Ordnance Department at Large throughout the United States will be filled from this examination. Apply for Form 1312.

Trade News

In order to care for expanding business on Yarway products, and give customers in the state of Michigan better service, Yarnall-Waring Co. has opened a branch office in the Builders and Traders Exchange, Penobscot Bldg., Detroit, in charge of Walter G. Heacock, Branch Manager.

Realizing the tremendous possibilities in the Orient for intensive sales development, the Pioneer Rubber Mills of San Francisco is planning to send its vice-president, D. D. Tripp, on an extended tour through that territory. Mr. Tripp will visit Japan, China, French Indo China, India, Straits Settlement, Java, Manila, Australia and other countries.

The C. T. Coe Co., of Chambersburg, Pa., has increased its capital stock from $250,000 to $500,000. It is less than a year ago (March, 1919), that the Coe Co. purchased the Hafer Foundry & Machine Co., to afford increased manufacturing facilities. On account of the increased business this capacity will now have to be doubled and the increase in capitalization is for that purpose. This will also afford the capacity to take care of accumulating orders and permit of rendering an efficient service in all lines.

The Chicago Pneumatic Tool Co. announces the appointment of Edw. A. Woodworth and C. E. Laverenz as special railroad representatives attached to the staff of manager of western railroad sales, with headquarters at Chicago.

Mr. Woodworth has been for several years secretary of the Committee on Standards, United States Railroad Administration, Washington, D. C. Prior to his engagement in the government service he was associated with the Oxweld Railroad Service Co. and O'Malley Barre Valve Co. He was formerly chief clerk to general mechanical superintendent of the Chicago, Rock Island & Pacific Railroad and has had earlier experience in the shops of that road as a mechanic.

Mr. Laverenz for several years was an inspector in the Ordnance Department of the United States Navy and previously held positions as boilermaker and foreman of the Chicago and Northwestern and Illinois Central Railroads.

Why Your Power Plant Needs a Venturi is the title of a four-page bulletin, No. 197, just published by Builders Iron Foundry, Providence, R. I.

Catalog No. 18 of Sherwood Mfg. Co., Buffalo, N. Y., describes and illustrates the company's engineering specialties, including oil pumps, strainers, valves, lubricators, flue cleaners and various others.

The latest catalog of Sanford Riley Stoker Co., Worcester, Mass., illustrating and describing Riley underfeed stokers, is for general distribution to those interested in boiler equipment.

Grinder Book No. 26, covering grinders and buffers, countershafts and presses for the heavy hardware, mill supply and automobile trade, has just been issued by Columbia Mfg. Co., Belleville, Ill. The company will gladly mail copies of this booklet to readers who are interested.

Worthington Pump and Machinery Corporation, 115 Broadway, New York, has just issued a new and complete catalog covering Worthington Condensing Apparatus, which is a 115-page book containing many illustrations, together with useful tables, notes and information.

Portable Belt Conveyors for handling material horizontally or at a slight incline are described and illustrated in a new folder entitled Type B Portable Belt Conveyors, just published by the Portable Machinery Co. of Passaic, N. J. These machines in addition to being used for handling coal, sand, crushed stone, fertilizer, etc., are being used for conveying many manufactured products, bagged material such as cement, etc. Used in series or in conjunction with fixed conveying systems, they afford a flexible, convenient and automatic conveying arrangement.

Saving Fuel is the title of a new 24-page booklet published by the Northern Equipment Co., Erie, Pa. It is based upon matter that was prepared for the United States Fuel Administration during the war. The booklet thoroughly compares hand and mechanical feeding with mechanical regulation. It shows in a convincing way what is to be desired in the way of scientific boiler feed regulation. Many charts and diagrams are shown to emphasize the value of scientific control. Editorials from publications and articles and letters by prominent engineers are reproduced.